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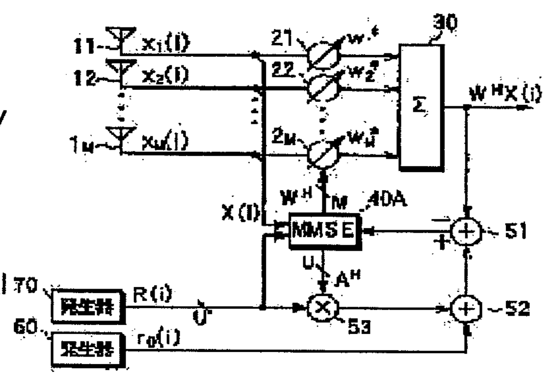
(54) ADAPTIVE ARRAY ANTENNA

(57)Abstract:
PROBLEM TO BE SOLVED: To provide an array antenna of an MMSE(minimum mean square error) system, in which wasteful consumption with respect to degrees of freedom is suppressed.
SOLUTION: A generator 60 generates a preamble signal r0(i) of an OFDM(orthogonal frequency division multiplexing) signal, and a generator 70 generates a delay signal R(i) for the signal r0(i). A multiplier 53 multiplies the delay signal R(i) by a signal weight AH to output a multiplied signal {AHR(i)}. A adder 52 outputs an added signal (r0(i)+AHR(i)). An adder 51 determines an error e (i), between the added signal and the inner product signal WHX(i) of an adder 30. An MMSE calculator 40a updates an antenna weight W and a signal weight A, to make the error e(i) small. The inner product signal WHX (i) of an adder 30 is made to be a signal formed, by suppressing the components of a received OFDM signal X(i), except for the preamble signal r0(i) and the delay signal AHR(i).



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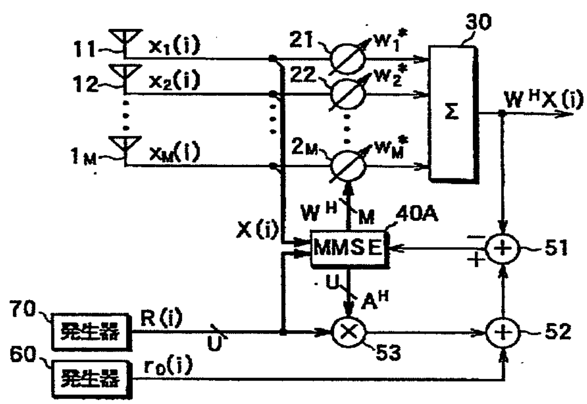
(54)【発明の名称】　アダプティブアレーアンテナ

(57)【要約】
【課題】　自由度の無駄な消費を抑えるようにしたＭＭＳＥ方式のアダプティブアレーアンテナを提供する。
【解決手段】　発生器６０はＯＦＤＭ信号のプリアンブル信号ｒ₀（ｉ）を発生し、発生器７０はプリアンブル信号ｒ₀（ｉ）に対する遅延信号Ｒ（ｉ）を発生する。乗算器５３は信号ウエイトＡ"を遅延信号Ｒ（ｉ）に乗算して乗算信号｛Ａ"Ｒ（ｉ）｝を出力する。加算器５２は、加算信号（ｒ₀（ｉ）＋Ａ"Ｒ（ｉ））を出力する。加算器５１は、加算信号と加算器３０の内積信号Ｗ"Ｘ（ｉ）との誤差ｅ（ｉ）を求める。ＭＭＳＥ演算器４０Ａは、誤差ｅ（ｉ）を小さくするようにアンテナウエイトＷ及び信号ウエイトＡを更新する。加算器３０の内積信号Ｗ"Ｘは、受信ＯＦＤＭ信号Ｘ（ｉ）のうちプリアンブル信号ｒ₀（ｉ）と遅延信号Ａ"Ｒ（ｉ）とを除く成分が抑圧された信号になる。



【特許請求の範囲】

【請求項１】　複数のアンテナ素子（１１…１Ｍ）と、前記複数のアンテナ素子で受信された受信信号にそれぞれのアンテナウエイトを乗算するアンテナ乗算手段（２１…２Ｍ）と、

前記アンテナウエイトが乗算されたそれぞれの受信信号を加算して加算信号を出力する加算手段（３０）と、

第１の既知信号及び第２の既知信号から参照信号を求める参照信号算出手段（５１～５３、５１Ａ、５３Ａ）と、

前記複数のアンテナ素子で受信された受信信号と前記加算信号と前記参照信号とに応じて前記アンテナウエイトを更新する更新手段（４０Ａ、４１）とを備えることを特徴とするアダプティブアレーアンテナ。

【請求項２】　前記第２の既知信号は、前記第１の既知信号に対して所定期間遅延した遅延信号であることを特徴とする請求項１に記載のアダプティブアレーアンテナ。

【請求項３】　前記第１の既知信号を前記所定期間遅延させて前記第２の既知信号を求める遅延手段（８０）を有することを特徴とする請求項２に記載のアダプティブアレーアンテナ。

【請求項４】　前記複数のアンテナ素子は、それぞれ、前記第１の既知信号の成分と前記第２の既知信号の成分とを有する信号を前記受信信号として受信し、

前記複数のアンテナ素子で受信された受信信号に基づいて、前記第１の既知信号の成分に対する前記第２の既知信号の成分の遅延時間を求める遅延時間算出手段（１００）を有し、

前記遅延手段は、前記所望既知信号を前記遅延時間だけ遅延させて前記第２の既知信号を求めることを特徴とする請求項２に記載のアダプティブアレーアンテナ。

【請求項５】　前記第１の既知信号に対してそれぞれ異なる時間だけ遅延したを複数の遅延信号を生成する遅延信号生成手段（９０）と、

前記複数の遅延信号と前記受信信号との相関検出を行う相関検出器（１３１ａ～１３４ｃ）と、

前記相関検出器の相関検出に基づいて前記複数の遅延信号の何れかを前記第２の既知信号として選択する選択手段（１３５ａ～１３６）とを有することを特徴とする請求項２に記載のアダプティブアレーアンテナ。

【請求項６】　前記参照信号算出手段は、前記第２の既知信号に信号ウエイトを乗算するウエイト乗算部（５３）を備え、この信号ウエイトが乗算された前記第２の既知信号に前記第１の既知信号を加算して前記参照信号を求め、

前記更新手段は、前記複数のアンテナ素子で受信された受信信号と前記第２の既知信号と前記参照信号と前記加算信号とに応じて前記信号ウエイトを更新することを特徴とする請求項１～５のうちいずれか１つに記載のアダプティブアレーアンテナ。

【請求項７】　前記加算手段の加算信号のうち前記第２の既知信号の成分を抑圧するために帰還信号を加算する抑圧手段（１２９、１３０）と、

前記加算信号を所定期間だけ遅延させて遅延加算信号を生成する加算信号遅延手段（１２１～１２４）と、

前記遅延加算信号に前記信号ウエイトを乗算して前記帰還信号を求める乗算手段（１２５～１２８）とを有することを特徴とする請求項６に記載のアダプティブアレーアンテナ。

【請求項８】　複数のアンテナ素子（１１…１Ｍ）と、前記複数のアンテナ素子で受信された受信ＯＦＤＭ信号をそれぞれ周波数弁別して弁別信号を求める受信周波数弁別手段（８０１～８０Ｍ）と、

前記周波数弁別されたそれぞれの弁別信号にアンテナウエイトを乗算するアンテナ乗算手段（２０１～２０Ｍ）と、

前記アンテナウエイトが乗算されたそれぞれの弁別信号を加算して加算信号を出力する加算手段（３００）と、

所望ＯＦＤＭ信号が周波数弁別された所望弁別信号を求める所望周波数分別手段（８４）と、

前記所望弁別信号に対して遅延した遅延弁別信号を求める遅延手段（９０、８３）と、

前記遅延弁別信号に信号ウエイトを乗算して、この信号ウエイトが乗算された前記遅延弁別信号に前記所望弁別信号を加算して参照信号を求める参照加算手段（５１０、５２０、５３０）と、

前記それぞれの弁別信号と前記遅延弁別信号とに応じて前記参照信号に前記加算信号を近づけるようにして、前記それぞれの弁別信号のうち前記所望弁別信号及び遅延弁別信号の双方を除く成分を抑圧するように前記アンテナウエイト及び前記信号ウエイトを更新する更新手段（４０Ｂ）とを備えることを特徴とするアダプティブアレーアンテナ。

【請求項９】　複数のアンテナ素子（１１～１４）と、前記複数のアンテナ素子で受信された受信ＯＦＤＭ信号をそれぞれ周波数弁別して弁別信号を求める受信周波数弁別手段（８０１～８０４）と、

前記周波数弁別されたそれぞれの弁別信号にアンテナウエイトを乗算するアンテナ乗算手段（２０１～２０４）と、

前記アンテナウエイトが乗算されたそれぞれの弁別信号を加算して加算信号を出力する加算手段（３００）と、

所望ＯＦＤＭ信号に対して所定期間遅延した遅延ＯＦＤＭ信号を求める遅延手段（８０Ａ）と、

前記所望ＯＦＤＭ信号及び前記遅延ＯＦＤＭ信号の双方が周波数弁別された所望弁別信号を求める所望周波数分別手段（８３４）と、

前記所望弁別信号に信号ウエイトを乗算して参照信号を求める参照加算手段（５３０Ａ）と、

前記参照信号と前記加算信号とを加算して加算参照信号を求める加算参照信号算出手段（５１０Ａ）と、
前記加算参照信号のうち、前記所望弁別信号の成分を除く成分の電力を小さくするように前記アンテナウエイト及び前記信号ウエイトを更新する更新手段（４２）とを備えることを特徴とするアダプティブアレーアンテナ。
【請求項１０】　既知信号が周波数軸上に配列されたプリアンブル信号を、前記所望ＯＦＤＭ信号として生成する生成手段（６０）を有することを特徴とする請求項８又は９に記載のアダプティブアレーアンテナ。
【請求項１１】　前記受信周波数弁別手段は、前記受信ＯＦＤＭ信号をサンプリグして各サンプリング信号を得て、前記各サンプリング信号に応じて前記弁別信号を求め、
前記遅延時間は、前記サンプリングの周期の所定倍数であることを特徴とする請求項１０に記載のアダプティブアレーアンテナ。
【請求項１２】　前記遅延手段は、所望個数の前記遅延弁別信号を出力することを特徴とする請求項８～１１のいずれか１つに記載のアダプティブアレーアンテナ。
【請求項１３】　前記遅延弁別信号の所望個数は、前記所望ＯＦＤＭ信号のデータ信号のガードインターバル期間と、前記サンプリングの周期と、によって決まる最大個数であることを特徴とする請求項１２に記載のアダプティブアレーアンテナ。
【請求項１４】　前記参照信号算出手段は、
前記第１及び第２の既知信号に信号ウエイトを乗算して前記参照信号を求める手段（５３Ａ）と、
前記参照信号と前記加算信号とを加算して加算参照信号を求める手段（５１Ａ）とを有し、
前記更新手段（４１）は、前記加算参照信号のうち、前記第１及び第２の既知信号を除く成分の電力を小さくするように前記アンテナウエイト及び前記信号ウエイトを更新することを特徴とする請求項２又は３に記載のアダプティブアレーアンテナ。
【請求項１５】　複数のアンテナ素子（１１～１４）と、
前記複数のアンテナ素子で受信された受信信号にそれぞれのアンテナウエイトを乗算するアンテナ乗算手段（２１…２４）と、
前記アンテナウエイトが乗算されたそれぞれの受信信号を加算して加算信号を出力する加算手段（３０）と、
前記複数のアンテナ素子で受信された受信信号のうち、これら受信信号の周波数帯域に比べて狭い周波数帯域の成分を示す受信周波数信号をそれぞれ出力する受信周波数信号出力手段（４２０～４２３）と、
既知信号のうち、前記狭い周波数帯域の成分を示す既知周波数信号を出力する既知周波数信号出力手段（４２４）と、
前記既知周波数信号に対して所定期間遅延した遅延周波数信号を求める遅延手段（８０Ａ）と、
前記遅延周波数信号及び前記既知周波数信号に信号ウエイトを乗算して参照信号を求める参照信号算出手段（５３Ａ）と、
前記参照信号と前記加算信号とを加算して加算参照信号を求める加算参照信号算出手段（５１Ａ）と、
前記加算参照信号のうち、前記遅延周波数信号及び前記既知周波数信号を除く成分の電力を小さくするように前記アンテナウエイト及び前記信号ウエイトを更新する更新手段（４１）とを有することを特徴とするアダプティブアレーアンテナ。
【請求項１６】　複数のアンテナ素子（１１、１２）と、
前記複数のアンテナ素子で受信された受信ＯＦＤＭ信号をそれぞれ周波数弁別して弁別信号を求める受信周波数弁別手段（８０１、８０２）と、
前記周波数弁別されたそれぞれの弁別信号にアンテナウエイトを乗算するアンテナ乗算手段（２０１、２０２）と、
前記アンテナウエイトが乗算されたそれぞれの弁別信号を加算して加算信号を出力する加算手段（３００）と、
既知ＯＦＤＭ信号を周波数弁別して既知弁別信号を求める既知周波数分別手段（８３）と、
前記既知弁別信号に対してそれぞれの位相量だけ位相回転して、前記それぞれの位相量に対応する位相回転既知弁別信号を求める位相回転手段（１０００）と、
前記それぞれの位相量に対応する位相回転既知弁別信号と前記それぞれの弁別信号との相関をとって、前記それぞれの位相量に対応する相関値を求める相関手段（１０１０）と、
前記それぞれの位相量に対応する相関値のうち、最大相関値を選択するとともに、前記それぞれの位相量に対応する位相回転既知弁別信号うち、前記最大相関値に対応する対応位相回転既知弁別信号を選択する選択手段（１０２０）と、
前記加算信号のうち、前記それぞれの位相量に対応する位相回転既知弁別信号を除く成分を小さくするとともに、前記加算信号のうち、前記対応位相回転既知弁別信号を少なくとも残すように前記アンテナウエイトを更新する更新手段（１０３４）とを有することを特徴とするアダプティブアレーアンテナ。
【請求項１７】　複数のアンテナ素子（１１、１２）と、
前記複数のアンテナ素子で受信された受信ＯＦＤＭ信号をそれぞれ周波数弁別して弁別信号を求める受信周波数弁別手段（８０１、８０２）と、
前記周波数弁別されたそれぞれの弁別信号にアンテナウエイトを乗算するアンテナ乗算手段（２０１、２０２）と、
前記アンテナウエイトが乗算されたそれぞれの弁別信号

を加算して加算信号を出力する加算手段（３００）と、前記それぞれの弁別信号のうち、前記弁別信号に比べて狭い周波数帯域の狭帯域弁別信号をそれぞれ出力する狭帯域出力手段（１０４０）と、
既知ＯＦＤＭ信号を周波数弁別して既知弁別信号を求める所望周波数分別手段（８３）と、
前記既知弁別信号のうち、前記既知弁別信号に比べて狭い周波数帯域の狭帯域既知弁別信号を出力する既知狭帯域出力手段（１０４１）と、
前記狭帯域既知弁別信号に対してそれぞれ異なる位相量だけ位相回転して、前記それぞれの位相量に対応する狭帯域の位相回転弁別信号を求める位相回転手段（１０００）と、
前記それぞれの位相量に対応する狭帯域の位相回転弁別信号と前記それぞれの弁別信号との相関をとって、前記それぞれの位相量に対応する相関値を求める相関手段（１０１０）と、
前記それぞれの位相量に対応する相関値のうち、最大相関値を選択するとともに、前記それぞれの狭帯域の位相回転弁別信号のうち、前記最大相関値に対応する狭帯域の位相回転弁別信号を選択する選択手段（１０２０）と、
前記加算信号のうち、前記それぞれの位相量に対応する狭帯域の位相回転既知弁別信号を除く成分を小さくするとともに、前記加算信号のうち、前記対応する狭帯域の位相回転弁別信号を少なくとも残すように前記アンテナウエイトを更新する更新手段（１０３３）とを有することを特徴とするアダプティブアレーアンテナ。
【請求項１８】　複数のアンテナ素子（１１、１２）と、
前記複数のアンテナ素子で受信された受信ＯＦＤＭ信号をそれぞれ周波数弁別して弁別信号を求める受信周波数弁別手段（８０１、８０２）と、
前記周波数弁別されたそれぞれの弁別信号にアンテナウエイトを乗算するアンテナ乗算手段（２０１、２０２）と、
前記アンテナウエイトが乗算されたそれぞれの弁別信号を加算して加算信号を出力する加算手段（３００）と、
前記それぞれの弁別信号のうち、前記弁別信号に比べて狭い周波数帯域の狭帯域弁別信号をそれぞれ出力する狭帯域出力手段（１０４０）と、
既知ＯＦＤＭ信号を周波数弁別して既知弁別信号を求める所望周波数分別手段（８３）と、
前記既知弁別信号のうち、前記既知弁別信号に比べて狭い周波数帯域の狭帯域既知弁別信号を出力する既知狭帯域出力手段（１０４１）と、
前記狭帯域既知弁別信号を位相回転する位相回転手段（１０００）と、前記加算信号のうち、前記狭帯域既知弁別信号と前記位相回転された狭帯域既知弁別信号とを除く成分の電力を小さくするように前記アンテナウエイトを更新する更新手段（１０３０Ａ）とを有することを特徴とするアダプティブアレーアンテナ。

【発明の詳細な説明】
【０００１】
【発明の属する技術分野】本発明は、アダプティブアレーアンテナに関する。
【０００２】
【従来の技術】近年、直交マルチキャリア方式の受信信号を受信するMMSE方式のアダプティブアレーアンテナが各種提案されている。先ず、直交マルチキャリア方式の信号（以下、直交マルチキャリア方式の信号をＯＦＤＭ信号という）の概略について図２５、図２６を参照して説明する。
【０００３】図２５に示すように、ＯＦＤＭ信号は、データ信号とこのデータ信号に先立つプリアンブル信号とから構成されている。プリアンブル信号は、周波数軸上に複数のパイロットシンボル（既知信号）を配列した信号である。データ信号は、時間多重された複数のＯＦＤＭシンボルからなり、ＯＦＤＭシンボルは、有効シンボルとこの有効シンボルに先だつガードインターバルＧＩとからなる。
【０００４】ガードインターバルＧＩは、有効シンボルうち、後側の所定期間部分を複写したものである。従って、図２６に示すように、所望のＯＦＤＭ信号とその遅延信号との和を受信信号として受信されたとき、所望のＯＦＤＭ信号に対する遅延信号の遅延時間がガードインターバルＧＩの期間ＴＧより短ければ、受信信号をＦＦＴ処理（周波数弁別処理）によって、データ（例えばＱＰＳＫシンボル）が復元可能である。
【０００５】次に、MMSE（Ｍｉｎｉｍｕｍ　Ｍｅａｎ　Ｓｑｕａｒｅ　Ｅｒｒｏｒ）方式のアダプティブアレーアンテナについて図２３を参照して説明する。図２７は、MMSE方式のアダプティブアレーアンテナの概略構成を示す。MMSE方式のアダプティブアレーアンテナは、アンテナ素子１１…１M、乗算器２１…２M、加算器（Σ）３０、MMSE演算器４０、加算器５０、及び、発生器６０から構成されている。なお、Mは、自然数である。
【０００６】アンテナ素子１１…１Mは、それぞれ、電波を媒体としてＯＦＤＭ信号を受信して、受信ＯＦＤＭ信号Ｘ（ｉ）を出力する。ここで、受信ＯＦＤＭ信号Ｘ（ｉ）は、数式１で表すことができる。Ｔは転置を示す。ｉは時刻を示す。
【０００７】
【数１】
$$X(i)=[x_1(i)\quad x_2(i)\quad \cdots\quad x_M(i)]^T$$
このため、アンテナ素子１１…１Mは、それぞれ、受信ＯＦＤＭ信号$x_1(i)$、$x_2(i)$、…$x_M(i)$を出力する。また、MMSE演算器５０は、乗算器２１、２

２…２ＭのそれぞれにアンテナウエイトW^Hに乗算する。

【０００８】ここで、アンテナウエイトW^Hを数式２で表すことができる。Ｈは複素共役転置である。

【０００９】

【数２】$W=[w_1\ w_2\ \cdots\ w_M]^T$

具体的には、乗算器２０は、アンテナウエイトw_1^*に受信ＯＦＤＭ信号x_1（ｉ）を乗算して乗算信号（$w_1^* x_1$（ｉ））を出力し、乗算器２１は、アンテナウエイトw_2^*に受信ＯＦＤＭ信号x_2（ｉ）を乗算して乗算信号（$w_2^* x_2$（ｉ））を出力する。乗算器２Ｍは、アンテナウエイトw_M^*に受信ＯＦＤＭ信号X_M（ｉ）を乗算して乗算信号（$w_M^* x_M$（ｉ））を出力する。

【００１０】加算器（Σ）３０は、乗算信号（$w_1^* x_1$（ｉ））、乗算信号（$w_2^* x_2$（ｉ））…乗算信号（$w_M^* x_M$（ｉ））を加算することにより、アンテナウエイトＷと受信ＯＦＤＭ信号Ｘ（ｉ）との内積を示す内積信号W^HＸ（ｉ）を求める。発生器６０は、参照信号r_0（ｉ）を予め記憶しこの参照信号r_0（ｉ）を加算器５０に出力し、加算器５０は、参照信号r_0（ｉ）と内積信号W^HＸ（ｉ）との誤差ｅ（ｉ）を求める｛ｅ（ｉ）＝r_0（ｉ）－W^HＸ（ｉ）｝。ＭＭＳＥ演算器４０は、受信ＯＦＤＭ信号Ｘ（ｉ）及び誤差ｅ（ｉ）を入力として、この誤差ｅ（ｉ）を小さくするようにアンテナウエイトＷを更新してそのアンテナウエイトＷを乗算器２１、２２…２Ｍに出力する。

【００１１】ここで、参照信号r_0（ｉ）として所望既知信号（例えば、時間軸上のプリアンブル信号）を採用することにより、受信ＯＦＤＭ信号Ｘ（ｉ）のうち、所望既知信号を除く遅延信号等を抑圧することができる。因みに、ＭＭＳＥ方式のアダプティブアレーアンテナにおいて、抑圧可能な既知信号（ヌル点）の数は、アンテナ素子の数により規定されて、（アンテナ素子数）－「１」である。以下、抑圧可能な既知信号（ヌル点）の数を自由度という。

【００１２】

【発明が解決しようとする課題】ところで、ＭＭＳＥ方式のアダプティブアレーアンテナでは、上述の如く、所望既知信号とその遅延信号との和を受信信号として受信したとき、所望既知信号に対する遅延信号の遅延時間が、ガードインターバルＧＩの期間ＴＧより短ければ、受信信号からデータ（図２６中のデータ１～データ４）を復元可能であるにも関わらず、当該遅延信号（以下、ＧＩ内遅延信号という）を抑圧することになる。

【００１３】このように、抑圧する必要が無く、且つ、復元して合成することが可能なＧＩ内遅延信号をも抑圧することにより、複数の信号を合成して受信性能を向上させることができなくなる。

【００１４】また、ＧＩ内遅延信号を抑圧するために、アダプティブアレーアンテナにおけるヌル点を形成することになるため、ＧＩ内遅延信号より遅延した遅延信号のように、本来ヌル点を形成するべき信号にヌル点を形成できなくなるという問題がある。すなわち、アダプティブアレーアンテナの自由度を無駄に消費することになる。

【００１５】本発明は、上記に鑑み、自由度の無駄な消費を抑えるようにしたアダプティブアレーアンテナを提供することを目的とする。

【００１６】

【課題を解決するための手段】本発明は、上記目的を達成するために、請求項１に記載の発明では、複数のアンテナ素子（１１…１Ｍ）と、複数のアンテナ素子で受信された受信信号にそれぞれのアンテナウエイトを乗算するアンテナ乗算手段（２１…２Ｍ）と、アンテナウエイトが乗算されたそれぞれの受信信号を加算して加算信号を出力する加算手段（３０）と、第１の既知信号及び第２の既知信号から参照信号を求める参照算出手段（５１～５３、５１Ａ、５３Ａ）と、複数のアンテナ素子で受信された受信信号と参照信号と加算信号とに応じてアンテナウエイトを更新する更新手段（４０Ａ、４１）とを備えることを特徴とする。

【００１７】ここで、参照信号は、第１及び第２の既知信号から算出されるもので、更新手段は、当該参照信号と上記受信信号と第２の既知信号と加算信号とに応じてアンテナウエイトを更新する。このため、更新手段は、アンテナウエイトの更新によって、複数のアンテナ素子で受信された受信信号のうち、第１及び第２の既知信号を除く成分を抑圧し得る。従って、第２の既知信号の抑圧が防止されるため、第２の既知信号の抑圧が無用である場合、本来、抑圧の必要の有る信号成分を抑圧できるので、ヌル点の形成を有効的に行うことができる。このため、アダプティブアレーアンテナの自由度の無駄な消費を抑える。

【００１８】また、受信信号のうち第１及び第２の既知信号を除く成分を抑圧するため、受信信号のうち、第１及び第２の既知信号の合成信号を得ることができる。ここで、請求項２に記載の発明のように、第２の既知信号は、前記第１の既知信号に対して所定期間遅延した遅延信号であるとき、第１の既知信号だけを復調する場合に比べて、第１及び第２の既知信号の合成信号を用いて復調する場合には、良好な復調信号を得られる。

【００１９】さらに、請求項３に記載の発明のように、第１の既知信号を所定期間遅延させて第２の既知信号を求める遅延手段（８０）を有するようにしてもよい。また、第２の既知信号を予め用意するのではなく、第２の既知信号を受信信号に応じて求めるようにしてもよい。

【００２０】すなわち、請求項４に記載の発明のように、複数のアンテナ素子は、それぞれ、第１の既知信号の成分と第２の既知信号の成分とを有する信号を受信信号として受信し、複数のアンテナ素子で受信された受信

信号に基づいて、第１の既知信号の成分に対する第２の既知信号の成分の遅延時間を求める遅延時間算出手段（１００）を有し、遅延手段は、所望既知信号を遅延時間だけ遅延させて第２の既知信号を求めるようにしてもよい。

【００２１】さらに、請求項５に記載の発明のように、第１の既知信号に対してそれぞれ異なる時間だけ遅延したを複数の遅延信号を生成する遅延信号生成手段（９０）と、遅延信号生成手段の各遅延信号と前記受信信号との相関検出を行う相関検出器（１３１ａ～１３４ｃ）と、相関検出器の相関検出に基づいて複数の遅延信号の何れかを第２の既知信号として選択する選択手段（１３５ａ～１３６）とを有するようにしてもよい。

【００２２】具体的には、請求項６に記載の発明のように、参照信号算出手段は、第２の既知信号に信号ウエイトを乗算して、この信号ウエイトが乗算された第２の既知信号に第１の既知信号を加算して参照信号を求め、更新手段は、複数のアンテナ素子で受信された受信信号と第２の既知信号と参照信号と加算信号とに応じて信号ウエイトを更新するようにしてもよい。

【００２３】ここで、請求項７に記載の発明では、加算手段の加算信号のうち第２の既知信号の成分を抑圧するために帰還信号を加算する抑圧手段（１２９、１３０）と、加算信号を所定期間だけ遅延させて遅延加算信号を生成する加算信号遅延手段（１２１～１２４）と、遅延加算信号に前記信号ウエイトを乗算して前記帰還信号を求める乗算手段（１２５～１２８）とを有することを特徴とする。これにより、抑圧手段は、加算信号のうち第２既知信号の成分を抑圧して第１の既知信号の成分だけを出力できる。

【００２４】請求項８に記載の発明では、複数のアンテナ素子（１１…１Ｍ）と、複数のアンテナ素子で受信された受信ＯＦＤＭ信号をそれぞれ周波数弁別して弁別信号を求める受信周波数弁別手段（８０１～８０Ｍ）と、周波数弁別されたそれぞれの弁別信号にアンテナウエイトを乗算するアンテナ乗算手段（２０１～２０Ｍ）と、アンテナウエイトが乗算されたそれぞれの弁別信号を加算して加算信号を出力する加算手段（３００）と、所望ＯＦＤＭ信号が周波数弁別された所望弁別信号を求める所望周波数分別手段（８４）と、所望弁別信号に対して遅延した遅延弁別信号を求める遅延手段（９０、８３）と、遅延弁別信号に信号ウエイトを乗算して、この信号ウエイトが乗算された遅延弁別信号に所望弁別信号を加算して参照信号を求める参照加算手段（５１０、５２０、５３０）と、前記それぞれの弁別信号と前記遅延弁別信号とに応じて前記参照信号に前記加算信号を近づけるようにして、前記それぞれの弁別信号のうち前記所望弁別信号及び遅延弁別信号の双方を除く成分を抑圧するように前記アンテナウエイト及び前記信号ウエイトを更新する更新手段（４０Ｂ）とを備えることを特徴とする。

【００２５】このように、更新手段は、それぞれの弁別信号のうち所望弁別信号及び遅延弁別信号の双方を除く成分を抑圧するようにアンテナウエイト及び信号ウエイトを更新する。このため、遅延弁別信号の抑圧が防止されるため、遅延弁別信号の抑圧が無用であるとき、本来、抑圧の必要の有る信号成分を抑圧できるので、ヌル点の形成を有効的に行うことができる。このため、アダプティブアレーアンテナの自由度の無駄な消費を抑える。

【００２６】また、更新手段は、上述の如く、それぞれの弁別信号のうち所望弁別信号及び遅延弁別信号の双方を除く成分を抑圧するようにアンテナウエイト及び信号ウエイトを更新するため、それぞれの弁別信号のうち所望弁別信号及び遅延弁別信号の双方を得られる。このような所望弁別信号及び遅延弁別信号の双方を用いて復調すれば、所望弁別信号だけで復調する場合に比べて、良好な復調信号が得られる。

【００２７】請求項９に記載の発明では、複数のアンテナ素子（１１～１４）と、前記複数のアンテナ素子で受信された受信ＯＦＤＭ信号をそれぞれ周波数弁別して弁別信号を求める受信周波数弁別手段（８０１～８０４）と、前記周波数弁別されたそれぞれの弁別信号にアンテナウエイトを乗算するアンテナ乗算手段（２０１～２０４）と、前記アンテナウエイトが乗算されたそれぞれの弁別信号を加算して加算信号を出力する加算手段（３００）と、所望ＯＦＤＭ信号に対して所定期間遅延した遅延ＯＦＤＭ信号を求める遅延手段（８０Ａ）と、前記所望ＯＦＤＭ信号及び前記遅延ＯＦＤＭ信号の双方が周波数弁別された所望弁別信号を求める所望周波数分別手段（８３４）と、前記所望弁別信号に信号ウエイトを乗算して参照信号を求める参照加算手段（５３０Ａ）と、前記参照信号と前記加算信号とを加算して加算参照信号を求める加算参照信号算出手段（５１０Ａ）と、前記加算参照信号のうち、前記所望弁別信号を除く成分の電力を小さくするように前記アンテナウエイト及び前記信号ウエイトを更新する更新手段（４２）とを備えることを特徴とする。

【００２８】このように、更新手段は加算参照信号のうち所望弁別信号をの成分を除く成分の電力を小さくするようにアンテナウエイト及び信号ウエイトを更新するため、加算参照信号のうち所望弁別信号の成分を除く成分の電力を小さくできる。従って、所望弁別信号の抑圧が防止される、すなわち、所望ＯＦＤＭ信号が周波数弁別された信号の抑圧が防止されるとともに、遅延ＯＦＤＭ信号が周波数弁別された信号の抑圧が防止される。

【００２９】このため、遅延ＯＦＤＭ信号が周波数弁別された信号の抑圧が無用である場合、本来、抑圧の必要の有る信号成分を抑圧できるので、ヌル点の形成を有効的に行うことができる。このため、アダプティブアレー

アンテナの自由度の無駄な消費を抑える。

【００３０】また、請求項１０に記載の発明のように、既知信号が周波数軸上に配列されたプリアンブル信号を、前記所望ＯＦＤＭ信号として生成する生成手段（６０）を有するようにしてもよい。さらに、請求項１１に記載の発明のように、受信周波数弁別手段は、受信ＯＦＤＭ信号をサンプリグして各サンプリング信号を得て、各サンプリング信号に応じて前記弁別信号を求め、遅延時間は、サンプリングの周期の所定倍数であるようにしてもよい。

【００３１】さらに、請求項１２に記載の発明では、遅延手段は、１つの遅延弁別信号だけに限らず、所望個数の前記遅延弁別信号を出力することを特徴とする。これにより、更新手段は、請求項１に記載の発明と同様に、前記それぞれの弁別信号のうち前記所望弁別信号及び所望個数の遅延弁別信号を除く成分を抑圧するように前記それぞれのアンテナウエイト及び信号ウエイトを更新することができる。

【００３２】さらに、請求項１３に記載の発明では、遅延弁別信号の所望個数は、所望ＯＦＤＭ信号のデータ信号のガードインターバル期間と、サンプリングの周期とによって決まる最大個数であることを特徴とする。これにより、より、一層、数多くの遅延弁別信号の抑圧を防止できるため、アダプティブアレーアンテナの自由度の無駄な消費を、効果的に、抑えることができる。なお、遅延弁別信号の最大個数は、｛（ガードインターバル期間／サンプリングの周期）－１｝である。

【００３３】請求項１４に記載の発明では、参照信号算出手段は、前記第１及び第２の既知信号に信号ウエイトを乗算して前記参照信号を求める手段（５３Ａ）と、前記参照信号と前記加算信号とを加算して加算参照信号を求める手段（５１Ａ）とを有し、前記更新手段（４１）は、前記加算参照信号のうち、前記第１及び第２の既知信号を除く成分の電力を小さくするように前記アンテナウエイト及び前記信号ウエイトを更新することを特徴とする。

【００３４】このように、更新手段（４１）は、加算参照信号のうち、第１及び第２の既知信号を除く成分の電力を小さくするようにアンテナウエイト及び信号ウエイトを更新するため、加算参照信号のうち、第１及び第２の既知信号を除く成分の電力を小さくできる。このため、第１及び第２の既知信号の抑制を防止でき、第２の既知信号の抑制が無用のとき、本来、抑圧の必要の有る信号成分を抑圧できるので、ヌル点の形成を有効的に行うことができる。

【００３５】請求項１５に記載の発明では、複数のアンテナ素子（１１～１４）と、前記複数のアンテナ素子で受信された受信信号にそれぞれのアンテナウエイトを乗算するアンテナ乗算手段（２１…２４）と、前記アンテナウエイトが乗算されたそれぞれの受信信号を加算して

加算信号を出力する加算手段（３０）と、前記複数のアンテナ素子で受信された受信信号のうち、これら受信信号の周波数帯域に比べて狭い周波数帯域の成分を示す受信周波数信号をそれぞれ出力する受信周波数信号出力手段（４２０～４２３）と、既知信号のうち、前記狭い周波数帯域の成分を示す既知周波数信号を出力する既知周波数信号出力手段（４２４）と、前記既知周波数信号に対して所定期間遅延した遅延周波数信号を求める遅延手段（８０Ａ）と、前記遅延周波数信号及び前記既知周波数信号に信号ウエイトを乗算して参照信号を求める参照信号算出手段（５３Ａ）と、前記参照信号と前記加算信号とを加算して加算参照信号を求める加算参照信号算出手段（５１Ａ）と、前記加算参照信号のうち、前記遅延周波数信号及び前記既知周波数信号を除く成分の電力を小さくするように前記アンテナウエイト及び前記信号ウエイトを更新する更新手段（４１）とを有することを特徴とする。

【００３６】このように、更新手段は、加算参照信号のうち、遅延周波数信号及び既知周波数信号を除く成分の電力を小さくするようにアンテナウエイト及び信号ウエイトを更新するため、加算参照信号のうち、遅延周波数信号及び既知周波数信号を除く成分の電力を小さくできる。このため、遅延周波数信号及び既知周波数信号の抑制を防止でき、遅延周波数信号の抑制が無用のとき、本来、抑圧の必要の有る信号成分を抑圧できるので、ヌル点の形成を有効的に行うことができる。

【００３７】ここで、アンテナウエイト及び信号ウエイトの更新回数は、受信信号の周波数帯域によって決まり、上述の如く、アンテナウエイト及び信号ウエイトの更新にあたり、受信信号に代えて、受信信号の周波数帯域に比べて狭い周波数帯域の既知周波数信号を用いているため、アンテナウエイト及び信号ウエイトの更新回数を減らすことができる。

【００３８】また、請求項１６に記載の発明では、複数のアンテナ素子（１１、１２）と、複数のアンテナ素子で受信された受信ＯＦＤＭ信号をそれぞれ周波数弁別して弁別信号を求める受信周波数弁別手段（８０１、８０２）と、周波数弁別されたそれぞれの弁別信号にアンテナウエイトを乗算するアンテナ乗算手段（２０１、２０２）と、アンテナウエイトが乗算されたそれぞれの弁別信号を加算して加算信号を出力する加算手段（３００）と、既知ＯＦＤＭ信号を周波数弁別して既知弁別信号を求める既知周波数分別手段（８３）と、既知弁別信号に対してそれぞれの位相量だけ位相回転して、それぞれの位相量に対応する位相回転既知弁別信号を求める位相回転手段（１０００）と、それぞれの位相量に対応する位相回転既知弁別信号とそれぞれの弁別信号との相関をとって、それぞれの位相量に対応する相関値を求める相関手段（１０１０）と、それぞれの位相量に対応する相関値のうち、最大相関値を選択するとともに、それぞれの

位相量に対応する位相回転既知弁別信号うち、最大相関値に対応する対応位相回転既知弁別信号を選択する選択手段（１０２０）と、加算信号のうち、それぞれの位相量に対応する位相回転既知弁別信号を除く成分を小さくするとともに、加算信号のうち、対応位相回転既知弁別信号を少なくとも残すようにアンテナウエイトを更新する更新手段（１０３４）とを有することを特徴とする。

【００３９】このように、更新手段は、加算信号のうち、それぞれの位相量に対応する位相回転既知弁別信号を除く成分を小さくするアンテナウエイトを更新する。従って、加算信号のうち、それぞれの位相量に対応する位相回転既知弁別信号を除く成分を小さくできる。このため、それぞれの位相量に対応する位相回転既知弁別信号の抑制を防止でき、それぞれの位相量に対応する位相回転既知弁別信号の抑制が無用のとき、本来、抑圧の必要の有る信号成分を抑圧できるので、ヌル点の形成を有効的に行うことができる。

【００４０】さらに、更新手段は、加算信号のうち、最大相関値に対応する対応位相回転既知弁別信号を少なくとも残すようにアンテナウエイトを更新する。従って、加算信号のうち、最大相関値に対応する対応位相回転既知弁別信号を少なくとも残すことができる。

【００４１】ここで、対応位相回転既知弁別信号は、それぞれの位相量に対応する位相回転既知弁別信号のうち、最大電力値の位相回転既知弁別信号に対応するため、対応位相回転既知弁別信号を残すことにより、受信電力値の大きな回転既知弁別信号を得ることができる。

【００４２】請求項１７に記載の発明では、複数のアンテナ素子（１１、１２）と、複数のアンテナ素子で受信された受信ＯＦＤＭ信号をそれぞれ周波数弁別して弁別信号を求める受信周波数弁別手段（８０１、８０２）と、周波数弁別されたそれぞれの弁別信号にアンテナウエイトを乗算するアンテナ乗算手段（２０１、２０２）と、アンテナウエイトが乗算されたそれぞれの弁別信号を加算して加算信号を出力する加算手段（３００）と、それぞれの弁別信号のうち、弁別信号に比べて狭い周波数帯域の狭帯域弁別信号をそれぞれ出力する狭帯域出力手段（１０４０）と、既知ＯＦＤＭ信号を周波数弁別して既知弁別信号を求める所望周波数分別手段（８３）と、既知弁別信号のうち、既知弁別信号に比べて狭い周波数帯域の狭帯域既知弁別信号を出力する既知狭帯域出力手段（１０４１）と、狭帯域既知弁別信号に対してそれぞれ異なる位相量だけ位相回転して、それぞれの位相量に対応する狭帯域の位相回転弁別信号を求める位相回転手段（１０００）と、それぞれの位相量に対応する狭帯域の位相回転弁別信号とそれぞれの弁別信号との相関をとって、それぞれの位相量に対応する相関値を求める相関手段（１０１０）と、それぞれの位相量に対応する相関値のうち、最大相関値を選択するとともに、それぞれの狭帯域の位相回転弁別信号のうち、最大相関値に対応する狭帯域の位相回転弁別信号を選択する選択手段（１０２０）と、加算信号のうち、それぞれの位相量に対応する狭帯域の位相回転既知弁別信号を除く成分を小さくするとともに、加算信号のうち、対応する狭帯域の位相回転弁別信号を少なくとも残すように更新する更新手段（１０３３）とを有することを特徴とする。

【００４３】このように、更新手段は、加算信号のうち、それぞれの位相量に対応する狭帯域の位相回転既知弁別信号を除く成分を小さくするアンテナウエイトを更新するため、加算信号のうち、それぞれの位相量に対応する狭帯域の位相回転既知弁別信号を除く成分を小さくできる。このため、それぞれの位相量に対応する狭帯域の位相回転既知弁別信号の抑制を防止でき、それぞれの位相量に対応する狭帯域の位相回転既知弁別信号の抑制が無用のとき、本来、抑圧の必要の有る信号成分を抑圧できるので、ヌル点の形成を有効的に行うことができる。

【００４４】さらに、更新手段は、加算信号のうち、最大相関値に対応する狭帯域の位相回転既知弁別信号を少なくとも残すようにアンテナウエイトを更新する。従って、加算信号のうち、最大相関値に対応する狭帯域の位相回転既知弁別信号を少なくとも残すことができる。

【００４５】ここで、前記対応する狭帯域の位相回転既知弁別信号は、それぞれの位相量に対応する位相回転既知弁別信号のうち、最大電力値の位相回転既知弁別信号に対応するため、前記対応する狭帯域の位相回転既知弁別信号を残すことにより、受信電力値の大きな回転既知弁別信号を得ることができる。

【００４６】ここで、更新手段がアンテナウエイトを更新するにあたり、狭帯域の位相回転弁別信号を用いているため、請求項１６に記載の発明に比べて、更新のための演算量を減らすことができる。

【００４７】請求項１８に記載の発明では、複数のアンテナ素子（１１、１２）と、複数のアンテナ素子で受信された受信ＯＦＤＭ信号をそれぞれ周波数弁別して弁別信号を求める受信周波数弁別手段（８０１、８０２）と、周波数弁別されたそれぞれの弁別信号にアンテナウエイトを乗算するアンテナ乗算手段（２０１、２０２）と、アンテナウエイトが乗算されたそれぞれの弁別信号を加算して加算信号を出力する加算手段（３００）と、それぞれの弁別信号のうち、弁別信号に比べて狭い周波数帯域の狭帯域弁別信号をそれぞれ出力する狭帯域出力手段（１０４０）と、既知ＯＦＤＭ信号を周波数弁別して既知弁別信号を求める所望周波数分別手段（８３）と、既知弁別信号のうち、既知弁別信号に比べて狭い周波数帯域の狭帯域既知弁別信号を出力する既知狭帯域出力手段（１０４１）と、狭帯域既知弁別信号を位相回転する位相回転手段（１０００）と、加算信号のうち、狭帯域既知弁別信号と前記位相回転された狭帯域既知弁別信号とを除く成分の電力を小さくするようにアンテナウ

エイトを更新する更新手段（１０３０Ａ）とを有することを特徴とする。

【００４８】このように、加算信号のうち、狭帯域既知弁別信号と位相回転された狭帯域既知弁別信号とを除く成分の電力を小さくするようにアンテナウエイトを更新するため、加算信号のうち、狭帯域既知弁別信号と前記位相回転された狭帯域既知弁別信号を除く成分の電力を小さくできる。このため、狭帯域既知弁別信号と前記位相回転された狭帯域既知弁別信号の抑制を防止でき、狭帯域既知弁別信号と前記位相回転された狭帯域既知弁別信号の抑制が無用のとき、本来、抑圧の必要の有る信号成分を抑圧できるので、ヌル点の形成を有効的に行うことができる。

【００４９】ここで、更新手段がアンテナウエイトを算出するにあたり、前記位相回転された狭帯域既知弁別信号と狭帯域の位相回転弁別信号を用いているため、更新のための演算量を減らすことができる。

【００５０】因みに、上記各手段の括弧内の符号は、後述する実施形態に記載の具体的手段との対応関係を示す一例である。

【００５１】

【発明の実施の形態】（第１実施形態）図１に、本発明の第１実施形態に係るＭＭＳＥ方式のアダプティブアレーアンテナを示す。本第１実施形態においては、ＭＭＳＥ方式のアダプティブアレーアンテナが、ＯＦＤＭ信号を受信する例を示す。図１は、ＭＭＳＥ方式のアダプティブアレーアンテナの概略構成をブロック図である。ＭＭＳＥ方式のアダプティブアレーアンテナは、図１に示すように、アンテナ素子１１…１Ｍ（Ｍは自然数）、乗算器２１…２Ｍ、加算器（Σ）３０、ＭＭＳＥ演算器４０Ａ、加算器５１、５２、乗算器５３、及び発生器６０、７０から構成されている。図１において、図１８中の符号と同一符号は、同一物、或いは、実質的同一物を示す。

【００５２】発生器６０は、所望既知信号として、ＯＦＤＭ信号のプリアンブル信号$r_0(i)$を発生し、このプリアンブル信号$r_0(i)$は、周波数軸上に複数のパイロットシンボル（既知信号）が配列された信号である。

【００５３】発生器７０は、プリアンブル信号$r_0(i)$に対するＵ（Ｕは自然数）個の遅延信号を、他の既知信号として、発生して、Ｕ個の遅延信号は、それぞれ、プリアンブル信号に対して異なる遅延時間を有する。但し、プリアンブル信号に対するＵ個の遅延信号のそれぞれの遅延時間は、ＯＦＤＭシンボルのガードインターバルＧＩの期間ＴＧに比べて短く、以下、Ｕ個の遅延信号を、数式３に示す遅延信号Ｒ（ｉ）とする。

【００５４】

【数３】

$$R(i) = [r_1(i) \quad r_2(i) \quad \cdots r_U(i)]^T$$

次に、乗算器５３は、数式４に表す信号ウエイトA^Hを遅延信号Ｒ（ｉ）に乗算して数式５に示す乗算信号｛$A^H R(i)$｝を出力する。

【００５５】

【数４】$A = [a_1 \ a_2 \ \cdots a_U]^T$

【００５６】

【数５】$A^H R(i) = a_1^* r_1(i) + a_2^* r_2(i) \cdots a_U^* r_U(i)$

次に、加算器５２は、プリアンブル信号$r_0(i)$と乗算信号$A^H R(i)$とを加算して加算信号（$r_0(i) + A^H R(i)$）を出力する。ここで、加算信号（$r_0(i) + A^H R(i)$）は、プリアンブル信号$r_0(i)$と遅延信号Ｒ（ｉ）との合成信号（参照信号）になる。そして、加算器５１は、加算信号（$r_0(i) + A^H R(i)$）と加算器３０の内積信号$W^H X(i)$との誤差ｅ（ｉ）を求める。ここで、誤差ｅ（ｉ）を数式６に表すことができる。

【００５７】

【数６】$e(i) = r_0(i) + A^H R(i) - W^H X$

次に、ＭＭＳＥ演算器４０Ａには、受信ＯＦＤＭ信号Ｘ（ｉ）、遅延信号Ｒ（ｉ）、及び、誤差ｅ（ｉ）が入力されて、ＭＭＳＥ演算器４０Ａは、例えば、ＭＭＳＥ方式のＳＭＩ（Ｓａｍｐｌｅ Ｍａｔｒｉｘ Ｉｎｖｅｒｓｉｏｎ）法に基づいて誤差ｅ（ｉ）を小さくするようにアンテナウエイトＷを更新して乗算器２１、２２…２Ｍに出力するとともに、ＭＭＳＥ方式のＳＭＩ法に基づいて誤差ｅ（ｉ）を小さくするように信号ウエイトＡを更新して乗算器５３に出力する。

【００５８】これにより、加算器３０の内積信号$W^H X$としては、受信ＯＦＤＭ信号Ｘ（ｉ）のうちプリアンブル信号$r_0(i)$（所望既知信号）と遅延信号Ｒ（ｉ）（他の既知信号）とを除く成分が抑圧された信号になる。

【００５９】ここで、信号ウエイトＡは、ＭＭＳＥ演算器４０Ａによって、プリアンブル信号$r_0(i)$（第１の既知信号）を基準とした遅延信号Ｒ（ｉ）（第２の既知信号）の位相差及び振幅差を示すように求められる。

【００６０】以下、本第１実施形態の特徴について述べる。先ず、プリアンブル信号r_0に対する遅延信号Ｒ（ｉ）の遅延時間は、上述の如く、ガードインターバルＧＩの期間ＴＧに比べて短いため、受信ＯＦＤＭ信号Ｘ（ｉ）のうち遅延信号Ｒ（ｉ）を抑圧することなく、加算器３０の内積信号$W^H X$をＦＦＴ処理（周波数弁別）によってデータ（例えば、ＱＰＳＫデータシンボル）を復元できる。

【００６１】すなわち、受信ＯＦＤＭ信号Ｘ（ｉ）のうち遅延信号Ｒ（ｉ）の抑圧が無用である。そこで、本第１実施形態では、上述の如く、加算器３０の内積信号$W^H X$として、受信ＯＦＤＭ信号Ｘ（ｉ）のうちプリアンブル信号$r_0(i)$と遅延信号$A^H R(i)$とを除く成分

が抑圧された信号が得られる。

【００６２】このため、遅延信号Ｒ（ｉ）の抑圧が防止されるため、本来、抑圧の必要の有る信号成分を抑圧できるので、ヌル点の形成を有効的に行うことができる。従って、ＭＭＳＥ方式のアダプティブアレーアンテナの自由度の無駄な消費を抑え得る。

【００６３】また、加算器３０の内積信号$W^H X$として、プリアンブル信号r_0（ｉ）と遅延信号Ｒ（ｉ）との加算信号（r_0（ｉ）＋A^HＲ（ｉ））が得られるため、この加算信号を復調すれば、プリアンブル信号r_0（ｉ）だけを復調する場合に比べて、良好な復調信号が得られる。

【００６４】ここで、図２において、シュミレーションの結果を示す。図２中、横軸は、ＭＭＳＥ方式のアダプティブアレーアンテナを基準とした受信電波の受信角度［ｄｅｇ］で、縦軸は、抑圧比（ｄＢ）である。鎖線は、従来のＭＭＳＥ方式のアダプティブアレーアンテナを用いたシュミレーションの結果を示す。実線は、本第１実施形態のＭＭＳＥ方式のアダプティブアレーアンテナを用いたシュミレーションの結果を示す。

【００６５】図２から分かるように、従来のＭＭＳＥ方式のアダプティブアレーアンテナでは、ＧＩ内遅延信号が抑圧されているが、本第１実施形態のＭＭＳＥ方式のアダプティブアレーアンテナでは、ＧＩ内遅延信号の抑圧が防止されている。但し、ＧＩ内遅延信号は、所望信号（プリアンブル信号r_0）に対して（ガードインターバルＧＩの）期間ＴＧに比べて短い遅延時間を有する遅延信号である。

【００６６】以下に、本第１実施形態でのＭＭＳＥ演算器４０ＡのＭＭＳＥ方式のＳＭＩアルゴリズムについて述べる。先ず、数式６に示す誤差ｅ（ｉ）を変形して、誤差ｅ（ｉ）を、数式７のように表すことができる。

【００６７】

【数７】

$$\begin{aligned} e(i) &= r_0(i) + R(i)A^H - W^H X \\ &= r_0(i) - \{W^H X - R(i)A^H\} \\ &= r_0(i) - Y^H Z(i) \end{aligned}$$

ここで、Ｙは、数式８に示すようにアンテナウエイトＷ、及び、信号ウエイトＡの双方を含めたウエイトで、Ｚ（ｉ）は、数式９に表すように、受信ＯＦＤＭ信号Ｘ（ｉ）及び遅延信号Ｒ（ｉ）の双方を含めた信号である。

【００６８】

【数８】$Y=[w_1\ w_2\ w_3\ \cdots\ w_M\ -a_1\ -a_2\ -a_3\ \cdots -a_U]^T$

【００６９】

【数９】$Z=[x_1(i)\ \ x_2(i)\ \ x_3(i)\cdots\cdots\ x_M(i)\ \ r_1(i)\ \ r_2(i)\ \ r_3(i)\cdots r_U(i)]^T$ＳＭＩアルゴリズムにおいは、数式１０に示す評価関数Ｑを直接最小化する。但し、αは、０＜α≦１の重み付け定数である。

【００７０】

【数１０】

$$Q(i)=\sum_{i=1}^{G}\alpha^{G-i}|e(i)|^2$$

【００７１】さらに、数式７のウエイトＹに関する勾配ベクトルをゼロとおいて、評価関数Ｑの最小二乗が数式１１のように得られる。この数式１１は、ウエイトＹ（Ｇ）を更新するための式を示す。但し、Ｇは、時間（サンプリグ時間）であって、Ｇは、ウエイトＹの更新回数（ステップ数）を示す。

【００７２】

【数１１】

$$Y(G)=B^{-1}(G)\,b(G)$$

【００７３】ここで、数式１１中のＢ、ｂを数式１２、数式１３を示す。

【００７４】

【数１２】

$$B=\sum_{i=1}^{G}\alpha^{G-i}Z(i)Z^H(i)$$

【００７５】

【数１３】

$$b(G)=\sum_{i=1}^{G}\alpha^{G-i}Z(i)r_0^*(i)$$

【００７６】（第２実施形態）上記第１実施形態では、遅延信号Ｒ（ｉ）（Ｕ個の遅延信号）を発生させるために発生器７０を採用した例について説明したが、これに限らず、発生器６０から出力されたプリアンブル信号を用いて遅延信号Ｒ（ｉ）を発生させるようにしてもよい。この場合の構成を図３、図４に示す。

【００７７】図３は、本第２実施形態のＭＭＳＥ方式のアダプティブアレーアンテナの構成を示すブロック図で、図４は、図３中の遅延回路（以下、遅延回路８０という）の詳細を示す図である。本第２実施形態では、図３に示すように、図１に示す発生器６０が削除されるとともに、遅延回路８０が採用されている。図３において、図１中の符号と同一符号は、同一物、或いは、実質的同一物を示す。

【００７８】遅延回路８０は、発生器６０と乗算器５３との間に配置されたものであって、発生器６０から出力されたプリアンブル信号を受けて、上記第１実施形態で述べた遅延信号Ｒ（ｉ）を出力する。

【００７９】具体的には、遅延回路８０は、図４に示すように、遅延器（Z^{-1}）８０１、８０２、８０３、…８０Ｕを直列接続して構成されており、遅延器８０１、８０２、８０３、…８０Ｕは、それぞれ対応する遅延信号r_1（ｉ）、r_2（ｉ）　、…r_U（ｉ）をＭＭＳＥ演算器４０Ａ及び乗算器５３に出力する。その他の作動、

効果は、上記第１実施形態と同様である。

【００８０】（第３実施形態）上記第１、第２実施形態では、ＭＭＳＥ方式のアダプティブアレーアンテナが、ＯＦＤＭ信号のプリンアンブル信号を時間軸上の信号として採用した例について説明したが、これに限らず、ＯＦＤＭ信号のプリンブル信号をＦＦＴ処理（周波数分別）した各弁別信号を採用するようにしてもよい。この場合の構成を、図５～図８に示す。図５は、本第３実施形態のアダプティブアレーアンテナの構成を示す図で、図６は、図５中のＦＦＴ回路８３の詳細構成を示す図である。図７は、図５の遅延回路９０の作動を示す図で、図８は、図６中のＦＦＴ回路の作動を示す図である。

【００８１】本第３実施形態では、図５に示すように、ＭＭＳＥ演算回路４０Ｂが、図１中のＭＭＳＥ演算回路４０Ａに代えて採用されて、乗算器２０１～２０Ｍが、図１中の乗算器２１～２Ｍに代えて採用されている。乗算器５１０～５３０が、図１中の乗算器５１～５３に代えて採用されている。さらに、ＦＦＴ回路８０１～８０Ｍ、８３、８４が追加されている。ＦＦＴ回路８０１は、アンテナ素子１１の受信ＯＦＤＭ信号x_1（ｉ）のプリンアンブル信号をＦＦＴ処理する。具体的には、ＦＦＴ回路８０１は、上記プリンアンブル信号の有効シンボル（図１７参照）毎にＮ（Ｎは自然数）回だけサンプリング（アナログデジタル変換）して各サンプリング信号に基づいてＦＦＴ処理して周波数毎の弁別信号ft_1（１）、ft_1（２）…ft_1（Ｎ）を出力し得る。ここで、弁別信号ft_1（１）、ft_1（２）…ft_1（Ｎ）を、まとめて、数式１４で表すことができる。また、Ｎは、上記有効シンボルのサンプリング回数であって、上記有効シンボルのＦＦＴのポイント数である。

【００８２】

【数１４】$FT_1(i)=[ft_1(1)\ \ ft_1(2)\ \ ft_1(3)\cdots ft_1(N)]^T$

ＦＦＴ回路８０２は、ＦＦＴ回路８０１と実質的に同様に、アンテナ素子１１の受信ＯＦＤＭ信号x_1（ｉ）のプリンアンブル信号をＦＦＴ処理して、周波数毎の弁別信号ft_2（１）、ft_2（２）…ft_2（Ｎ）を出力する。さらに、弁別信号ft_2（１）、ft_2（２）…ft_2（Ｎ）を、まとめて、数式１５で表せる。

【００８３】

【数１５】$FT_2(i)=[ft_2(1)\ \ ft_2(2)\ \ ft_2(3)\cdots ft_2(N)]^T$

ＦＦＴ回路８０Ｍは、ＦＦＴ回路８０１と実質的に同様に、アンテナ素子１Ｍの受信ＯＦＤＭ信号x_M（ｉ）のプリンアンブル信号をＦＦＴ処理して、周波数毎の弁別信号ft_M（１）、ft_M（２）…ft_M（Ｎ）を出力する。さらに、弁別信号ft_M（１）、ft_M（２）…ft_M（Ｎ）を、まとめて、数式１６で表せる。

【００８４】

【数１６】$FT_M(i)=[ft_M(1)\ \ ft_M(2)\ \ ft_M(3)\cdots ft_M(N)]^T$

ここで、本第３実施形態では、、FT_1（ｉ）、FT_2（ｉ）、…FT_M（ｉ）をまとめて、数式１７に示すように、弁別信号Ｘ（ｉ）’とする

【００８５】

【数１７】$X(i)'=[FT_1(i)\ \ FT_2(i)\cdots FT_M(i)]^T$

次に、乗算器２０１～２０Ｍは、アンテナウエイトW^Hに弁別信号Ｘ（ｉ）’に乗算する。すなわち、乗算器２０１は、アンテナウエイトw_1^*とFT_1（ｉ）との積を求めて結果（$w_1^*FT_1(i)$）を得る。乗算器２０２は、アンテナウエイトw_2^*とFT_2（ｉ）との積を求めて結果（$w_2^*FT_2(i)$）を得る。さらに、乗算器２０Ｍは、アンテナウエイトw_M^*とFT_M（ｉ）との積を求めて結果（$w_M^*FT_M(i)$）を得る。

【００８６】次に、加算器（Σ）３００は、乗算器２０１～２０Ｍによる結果（$w_1^*FT_1(i)$）、（$w_2^*FT_2(i)$）、…（$w_M^*FT_M(i)$）を周波数毎に加算することにより、アンテナウエイトＷと弁別信号Ｘ（ｉ）’との内積を示す内積信号$W^H X(i)'$を求める。

【００８７】因みに、内積信号$W^H X(i)'$としては、数式１８に示すように、fx_1（１）、fx_2（２）、…fx_M（Ｎ）といったＮ個の内積信号をまとめたものである。さらに、例えば、内積信号はfx_1（１）は、数式１９で表すことができ、内積信号fx_2（２）は、数式２０で表すことができる。さらに、内積信号fx_M（Ｎ）は、数式２１で表すことができる。

【００８８】

【数１８】$W^H X(i)'=[fx_1(1)\ \ fx_2(2)\ \ \cdots fx_M(N)]^T$

【００８９】

【数１９】$fx_1(1)=w_1^*\cdot ft_1(1)+w_2^*\cdot ft_2(1)\cdots w_M^*\cdot ft_M(1)$

【００９０】

【数２０】$fx_2(2)=w_1^*\cdot ft_1(2)+w_2^*\cdot ft_2(2)\cdots w_M^*\cdot ft_M(2)$

【００９１】

【数２１】$fx_M(N)=w_1^*\cdot ft_1(N)+w_2^*\cdot ft_2(N)\cdots w_M^*\cdot ft_M(N)$

次に、遅延回路９０は、図６に示すように、発生器６０からのＯＦＤＭ信号のプリアンブル信号r_0（ｉ）（所望既知信号）を受けて、このプリアンブル信号r_0（ｉ）に対する遅延プリアンブル信号ＯＦ（$t+t_s$）、ＯＦ（$t+2\cdot t_s$）、ＯＦ（$t+3\cdot t_s$）…ＯＦ（$t+p\cdot t_s$）を発生する。

【００９２】但し、t_sは、ＦＦＴ回路８０１～８０Ｍのサンプリング周期を示す時間で、（ｐ＋１）は、ＯＦＤＭシンボルのガードインターバルＧＩを時間t_sでサンプリングした場合のサンプリングの回数である。

【００９３】これにより、遅延プリアンブル信号ＯＦ（ｔ＋t_s）、ＯＦ（ｔ＋２・t_s）…ＯＦ（ｔ＋ｐ・t_s）は、それぞれ、プリアンブル信号r_0（ｉ）に対してガードインターバル期間T_Gより短い遅延時間を有する。さらに、遅延プリアンブル信号の個数としては、ガードインターバル期間T_Gとサンプリング周期t_sとで定める最大個数である｛ｐ＝（T_G／t_s）－１｝。

【００９４】ここで、遅延プリアンブル信号ＯＦ（ｔ＋t_s）は、図７に示すように、プリアンブル信号r_0（ｉ）に対して時間t_sだけ遅延させた信号で、遅延プリアンブル信号ＯＦ（ｔ＋２・t_s）は、プリアンブル信号r_0（ｉ）に対して時間２t_sだけ遅延させた信号で、遅延プリアンブル信号ＯＦ（ｔ＋３・t_s）は、プリアンブル信号r_0（ｉ）に対して時間３・t_sだけ遅延させた信号である。遅延プリアンブル信号ＯＦ（ｔ＋ｐ・t_s）は、プリアンブル信号r_0（ｉ）に対して時間ｐ・t_sだけ遅延させた信号である。

【００９５】次に、ＦＦＴ回路８３は、図６に示すように、遅延回路９０からの遅延プリアンブル信号ＯＦ（ｔ＋t_s）、ＯＦ（ｔ＋２・t_s）、ＯＦ（ｔ＋３・t_s）…ＯＦ（ｔ＋ｐ・t_s）のそれぞれの有効シンボルを並列的にサンプリング周期t_sでサンプリングしてそのサンプリング信号でＦＦＴ処理する。具体的には、ＦＦＴ回路８３は、ＦＦＴ処理部８３１、８３２、８３３…８３ｐを有し、ＦＦＴ処理部８３１は、図８に示すように、遅延プリアンブル信号ＯＦ（ｔ＋t_s）の有効シンボルをサンプリング周期t_sでＦＦＴ処理して遅延弁別信号Ｒ（１）を出力する。但し、遅延弁別信号Ｒ（１）は、数式２２で表せる。この遅延弁別信号Ｒ（１）は、周波数毎の信号成分を有する。

【００９６】

【数２２】$R(1)=「f_1(1)\quad f_1(2)\quad f_1(3)\cdots f_1(N)」^T$

また、ＦＦＴ処理部８３２は、図８に示すように、遅延プリアンブル信号ＯＦ（ｔ＋２・t_s）の有効シンボルをサンプリング周期t_sでＦＦＴ処理することにより、数式２３に示す遅延弁別信号Ｒ（２）を出力する。この遅延弁別信号Ｒ（２）は、周波数毎の信号成分を有する。さらに、ＦＦＴ処理部８３ｐは、図８に示すように、遅延プリアンブル信号ＯＦ（ｔ＋ｐ・t_s）の有効シンボルをサンプリング周期t_sでＦＦＴ処理することにより、数式２４に示す遅延弁別信号Ｒ（ｐ）を出力する。遅延弁別信号Ｒ（ｐ）は、周波数毎の信号成分を有する。

【００９７】

【数２３】$R(2)=「f_2(1)\quad f_2(2)\quad f_2(3)\cdots f_2(N)」^T$

【００９８】

【数２４】$R(p)=「f_p(1)\quad f_p(2)\quad f_p(3)\cdots f_p(N)」^T$

次に、図５に示すＦＦＴ回路８４は、図８に示すように、発生器６０からのＯＦＤＭ信号のプリアンブル信号r_0（ｉ）（＝ＯＦ（ｔ））の有効シンボルをサンプリング周期t_sでサンプリングしてこれらサンプリング信号でＦＦＴ処理する。これにより、ＦＦＴ回路８４は、数式２５に示すように、所望弁別信号r_0（ｉ）’を出力する。所望弁別信号r_0（ｉ）’は、周波数毎の信号成分を有する。

【００９９】

【数２５】$r_0(i)'=「f_0(1)\quad f_0(2)\quad f_0(3)\cdots f_0(N)」^T$

次に、乗算器５３０は、信号ウエイトA^Hと遅延弁別信号Ｒ（ｉ）との積をとって出力信号｛A^HＲ（ｉ）｝を出力する。但し、本第３実施形態での信号ウエイトＡは、数式２６に示すようになっている。なお、出力信号｛A^HＲ（ｉ）｝は、Ｎ個の出力信号をまとめて表記されたものである。

【０１００】

【数２６】$A=[a_1\ a_2\cdots a_p]^T$

さらに、加算器５２０は、乗算器５３０の出力信号｛A^HＲ（ｉ）｝と所望弁別信号r_0（ｉ）’とを加算して加算信号（r_0（ｉ）’＋A^HＲ（ｉ））を出力する。加算器５１０は、加算信号（r_0（ｉ）’＋A^HＲ（ｉ））と加算器３０の内積信号W^HＸ（ｉ）’との誤差ｅ（ｉ）を求める。

【０１０１】ここで、ＭＭＳＥ演算器４０Ｂには、弁別信号Ｘ（ｉ）’、遅延弁別信号Ｒ（ｉ）、及び、誤差ｅ（ｉ）が入力されて、ＭＭＳＥ演算器４０Ｂは、上記第１、第２実施形態と同様に、ＭＭＳＥ方式のＳＭＩ法に基づいて誤差ｅ（ｉ）を小さくするようにアンテナウエイトＷを更新するとともに、信号ウエイトＡを更新する。これにより、加算器３００の内積信号W^HＸ（ｉ）’としては、弁別信号Ｘ（ｉ）’のうち所望弁別信号r_0（ｉ）’（所望既知信号）と遅延弁別信号Ｒ（ｉ）（他の既知信号）とを除く成分が抑圧された信号になる。これにより、上記第１、第２実施形態と実質的に同様の効果が得られる。

【０１０２】なお、上記第３実施形態では、遅延プリアンブル信号ＯＦ（ｔ＋t_s）、ＯＦ（ｔ＋２・t_s）、ＯＦ（ｔ＋３・t_s）…ＯＦ（ｔ＋ｐ・t_s）に基づいて遅延弁別信号Ｒ（ｉ）を得るようにした例について説明したが、これに限らず、所望弁別信号r_0（ｉ）’に基づいて遅延弁別信号Ｒ（ｉ）を得てもよい。

【０１０３】（第４実施形態）上記第１～３実施形態では、ＭＭＳＥ方式のアダプティブアレーアンテナが、ＯＦＤＭ信号を受信する例について説明したが、これに限らず、ＭＭＳＥ方式のアダプティブアレーアンテナをＣＤＭＡ通信に適用してもよい。この場合の構成を図９に示す。

【０１０４】図９では、図３に示す回路にマッチドフィ

ルタ１００及びＲＡＫＥ合成器１１０が追加されて構成されている。さらに、図３に示す遅延回路８０に代えて、遅延回路８０Ａが採用されている。図９において、図１中の符号と同一符号は、同一物、或いは、実質的同一物を示す。但し、各アンテナ素子１１…１ＭがＯＦＤＭ信号に代えてＣＤＭＡ信号を受信して、受信ＣＤＭＡ信号x_1（ｉ）、x_2（ｉ）、…x_M（ｉ）を出力する。

【０１０５】次に、本第４実施形態の作動について図１０を参照して説明する。以下、４個のアンテナ素子１１～１４を採用して、アンテナ素子１１～１４がそれぞれ、を出力する例について説明する。マッチドフィルタ１００は、受信ＣＤＭＡ信号x_1（ｉ）、x_2（ｉ）、x_3（ｉ）、x_4（ｉ）をそれぞれと発生器６０からのパイロット信号（既知信号）r_0（ｉ）との相関検出を並列的に行う。

【０１０６】具体的には、マッチドフィルタ１００は、第１～第４のマッチドフィルタ部（図示せず）を有している。第１のマッチドフィルタ部は、受信ＣＤＭＡ信号x_1（ｉ）とパイロット信号r_0（ｉ）との相関検出をして相関信号（図１０（ａ）参照）を出力し、第２のマッチドフィルタ部は、受信ＣＤＭＡ信号x_2（ｉ）とパイロット信号r_0（ｉ）との相関検出をして相関信号（図１０（ｂ）参照）を出力する。

【０１０７】第３のマッチドフィルタ部は、受信ＣＤＭＡ信号x_3（ｉ）とパイロット信号r_0（ｉ）との相関検出をして相関信号（図１０（ｃ）参照）を出力し、第４のマッチドフィルタ部は、受信ＣＤＭＡ信号x_4（ｉ）とパイロット信号r_0（ｉ）との相関検出をして相関信号（図１０（ｄ）参照）を出力する。但し、図１０（ａ）～（ｄ）では、縦軸は、相関値を示し、横軸は時間を示す。

【０１０８】ここで、マッチドフィルタ１００は、第１～第４のマッチドフィルタ部からの相関信号を加算してその加算結果に基づいて、パイロット信号r_0（ｉ）（所望信号）の入力時を基準とした遅延情報を得る。この遅延情報は、受信ＣＤＭＡ信号x_1（ｉ）～x_4（ｉ）のうち所望の時間より短い遅延時間の遅延信号を示すものである。図１０（ｅ）に示す例では、遅延情報としては、ｔｄ１、ｔｄ２、ｔｄ３、～ｔｄ６が得られるた例を示す。そこで、遅延回路８０Ａは、遅延情報ｔｄ１～ｔｄ６を用いて、図１０（ｆ）に示すように、遅延信号Ｒ（ｉ）（他の既知信号）を出力する。

【０１０９】すなわち、遅延回路８０Ａは、r_0（ｔ＋ｔｄ１）、r_0（ｔ＋ｔｄ２）、r_0（ｔ＋ｔｄ２）…r_0（ｔ＋ｔｄ６）を出力する。例えば、r_0（ｔ＋ｔｄ１）は、パイロット信号r_0（ｉ）に対して遅延時間ｔｄ１だけ遅延しており、r_0（ｔ＋ｔｄ２）は、パイロット信号r_0（ｉ）に対して遅延時間ｔｄ２だけ遅延している。r_0（ｔ＋ｔｄ６）は、パイロット信号r_0（ｉ）に対して遅延時間ｔｄ６だけ遅延している。その他の作動は、図３に示す回路と実質的に同様である。

【０１１０】以上により、加算器（Σ）からの内積信号$W^H X$としては、受信ＣＤＭＡ信号x_1（ｉ）…x_M（ｉ）のうちパイロット信号r_0（ｉ）（所望信号）及びその遅延信号r_0（ｔ＋ｔｄ１）～r_0（ｔ＋ｔｄ６）（他の既知信号）を除く成分が抑圧された信号が得られる。そして、ＲＡＫＥ合成器１１０は、当該内積信号$W^H X$を用いて、ＲＡＫＥ合成復調を行うことになる。ここで、遅延信号r_0（ｔ＋ｔｄ１）～r_0（ｔ＋ｔｄ６）として、ＲＡＫＥ合成復調に必要な信号を用意すれば、ＲＡＫＥ合成復調に不必要な信号の抑圧のためにヌル点を形成できる。従って、上記第１実施形態と同様に、ＭＭＳＥ方式のアダプティブアレーアンテナの自由度の無駄な消費を抑え得る。

【０１１１】なお、上記第４実施形態においては、ＣＤＭＡ方式の通信にＭＭＳＥ方式のアダプティブアレーアンテナを適用して、マッチドフィルタ１００でＣＤＭＡ受信信号Ｘ（ｉ）の遅延情報を得る例を示したが、これに限らず、上記第１、第２実施形態の受信ＯＦＤＭ信号の遅延情報をマッチドフィルタ１００で得るようにしてもよい。

【０１１２】（第５実施形態）上記２実施形態では、所望既知信号及び他の既知信号及びを予め設定した例について説明したが、これに限らず、受信ＯＦＤＭ信号Ｘ（ｉ）に応じて、遅延信号Ｒ（ｉ）のうち所望既知信号及び他の既知信号を選択するようにしてもよい。

【０１１３】この場合の構成を図１１、図１２に示す。図１１は、本第５実施形態でのＭＭＳＥ方式のアダプティブアレーアンテナの構成を示す。図１２は、図１１中の所望信号選択回路（以下、所望信号選択回路１３０）の詳細構成を示す。

【０１１４】本第５実施形態のＭＭＳＥ方式のアダプティブアレーアンテナは、図１１に示すように、図３に示す回路に所望信号選択回路１３０が追加されている。図１１において、図３の示す同一符号は、同一物、或いは、実質的に同一物を示す。

【０１１５】遅延回路９０は、発生器６０からのプリアンブル信号r_0（ｉ）を受けて、遅延プリアンブル信号ＯＦ（$t+t_s$）、ＯＦ（$t+2\cdot t_s$）…ＯＦ（$t+U\cdot t_s$）を発生する。但し、Ｕは自然数であって、プリアンブル信号r_0（ｉ）に対する遅延プリアンブル信号ＯＦ（$t+t_s$）…ＯＦ（$t+U\cdot t_s$）のそれぞれの遅延時間は、ＯＦＤＭ信号のガードインターバル期間T_Gに比べて短い。

【０１１６】所望信号選択回路１３０には、受信ＯＦＤＭ信号Ｘ（ｉ）及び遅延プリアンブル信号ＯＦ（$t+t_s$）…ＯＦ（$t+U\cdot t_s$）が入力されて、所望信号選択回路１３０は、受信ＯＦＤＭ信号Ｘ（ｉ）に応じて、遅延プリアンブル信号ＯＦ（$t+t_s$）…ＯＦ（$t+U\cdot$

t_s）のうち所望既知信号r_0（ｉ）’及び遅延信号Ｒ（ｉ）を選択する。

【０１１７】具体的には、所望信号選択回路１３０は、図１２に示すように、相関器１３１ａ～１３１ｃ、１３２ａ～１３２ｃ、１３３ａ～１３３ｃ、１３４ａ～１３４ｃ、加算器（Σ）１３５ａ～１３５ｃ、最大値判定器１３６、及び、選択回路１３７から構成されている。

【０１１８】次に、本第５実施形態の作動について図１２を参照して説明する。以下、アンテナ素子１１～１４といった４つのアンテナ素子だけを採用し、遅延プリアンブル信号ＯＦ（ｔ＋t_s）、ＯＦ（ｔ＋２・t_s）、ＯＦ（ｔ＋３・t_s）といった３個の遅延プリアンブル信号を採用した例について説明する。先ず、アンテナ素子１１～１４は、受信ＯＦＤＭ信号x_1（ｉ）、x_2（ｉ）、x_3（ｉ）、x_4（ｉ）を、それぞれ、出力する。

【０１１９】次に、相関器１３１ａは、遅延プリアンブル信号ＯＦ（ｔ＋t_s）と受信ＯＦＤＭ信号x_1（ｉ）との相関検出を行い、相関器１３２ａは、遅延プリアンブル信号ＯＦ（ｔ＋t_s）と受信ＯＦＤＭ信号x_2（ｉ）との相関検出を行う。相関器１３３ａは、遅延プリアンブル信号ＯＦ（ｔ＋t_s）と受信ＯＦＤＭ信号x_3（ｉ）との相関検出を行い、相関器１３４ａは、遅延プリアンブル信号ＯＦ（ｔ＋t_s）と受信ＯＦＤＭ信号x_4（ｉ）との相関検出を行う。

【０１２０】加算器１３５ａは、相関器１３１ａ、１３２ａ、１３３ａ、１３４ａのそれぞれからの相関検出信号を加算して加算信号を出力する。ここで、加算器１３５ａの加算信号は、遅延プリアンブル信号ＯＦ（ｔ＋t_s）と、受信ＯＦＤＭ信号x_1（ｉ）、x_2（ｉ）、x_3（ｉ）、x_4（ｉ）との相関を示す。

【０１２１】次に、相関器１３１ｂは、遅延プリアンブル信号ＯＦ（ｔ＋２・t_s）と受信ＯＦＤＭ信号x_1（ｉ）との相関検出を行い、相関器１３２ｂは、遅延プリアンブル信号ＯＦ（ｔ＋２・t_s）と受信ＯＦＤＭ信号x_2（ｉ）との相関検出を行う。相関器１３３ｂは、遅延プリアンブル信号ＯＦ（ｔ＋２・t_s）と受信ＯＦＤＭ信号x_3（ｉ）との相関検出を行い、相関器１３４ｂは、遅延プリアンブル信号ＯＦ（ｔ＋２・t_s）と受信ＯＦＤＭ信号x_4（ｉ）との相関検出を行う。

【０１２２】加算器１３５ｂは、相関器１３１ｂ、１３２ｂ、１３３ｂ、１３４ｂのそれぞれからの相関検出信号を加算して加算信号を出力する。加算器１３５ｂの加算信号は、遅延プリアンブル信号ＯＦ（ｔ＋２・t_s）と、受信ＯＦＤＭ信号x_1（ｉ）、x_2（ｉ）、x_3（ｉ）、x_4（ｉ）との相関を示す。

【０１２３】次に、相関器１３１ｃは、遅延プリアンブル信号ＯＦ（ｔ＋３・t_s）と受信ＯＦＤＭ信号x_1（ｉ）との相関検出を行い、相関器１３２ｃは、遅延プリアンブル信号ＯＦ（ｔ＋３・t_s）と受信ＯＦＤＭ信号x_2（ｉ）との相関検出を行う。相関器１３３ｃは、遅延プリアンブル信号ＯＦ（ｔ＋３・t_s）と受信ＯＦＤＭ信号x_3（ｉ）との相関検出を行い、相関器１３４ｃは、遅延プリアンブル信号ＯＦ（ｔ＋３・t_s）と受信ＯＦＤＭ信号x_4（ｉ）との相関検出を行う。

【０１２４】加算器１３５ｃは、相関器１３１ｃ、１３２ｃ、１３３ｃ、１３４ｃのそれぞれからの相関検出信号を加算して加算信号を出力する。加算器１３５ｃの加算信号は、遅延プリアンブル信号ＯＦ（ｔ＋３・t_s）と、受信ＯＦＤＭ信号x_1（ｉ）、x_2（ｉ）、x_3（ｉ）、x_4（ｉ）との相関を示す。

【０１２５】次に、最大値判定器１３６は、加算器１３５ａ～１３５ｃからのそれぞれの加算信号のうち最大値となる加算信号（以下、最大値加算信号という）を判定し、この最大値加算信号を示す最大値識別信号を選択回路１３７に出力する。選択回路１３７は、遅延プリアンブル信号ＯＦ（ｔ＋t_s）、ＯＦ（ｔ＋２・t_s）、ＯＦ（ｔ＋３・t_s）のうち、最大値識別信号に対応する遅延プリアンブル信号を所望既知信号ｒ（ｉ）’として選択して出力する。さらに、選択回路１３７は、遅延プリアンブル信号ＯＦ（ｔ＋t_s）、ＯＦ（ｔ＋２・t_s）、ＯＦ（ｔ＋３・t_s）のうち、最大値識別信号に対応する遅延プリアンブル信号を除く、２つの遅延プリアンブル信号を他の既知信号Ｒ（ｉ）として出力する。その他の作動は、上記第２実施形態と実質的に同様である。

【０１２６】なお、上記第５実施形態においては、４つのアンテナ素子１１～１４を採用した例について説明したが、これに限らず、アンテナ素子の個数は、２個以上であるならば、幾つでもよい。さらに、上記第５実施形態では、３個の遅延プリアンブル信号ＯＦ（ｔ＋t_s）、ＯＦ（ｔ＋２・t_s）、ＯＦ（ｔ＋３・t_s）を採用した例につき説明したが、これに限らず、遅延プリアンブル信号の個数は、幾つでもよい。

【０１２７】なお、本発明の実施にあたり、本第５実施形態に示す相関器としては、スライデング相関器、マッチドフィルタ等の各種相関器を適用してもよい。

【０１２８】（第６実施形態）本第６実施形態では、上記第２実施形態の回路に等化回路（以下、等化回路１２０という）が追加された回路が採用され、等化回路１２０によって、加算器３０の内積信号W"Ｘ（ｉ）のうち他の既知信号を抑圧しその抑圧された信号を出力信号として出力する。この場合の構成を図１３、図１４に示す。

【０１２９】図１３は、本第６実施形態のＭＭＳＥ方式のアダプティブアレーアンテナの構成を示す図である。図１４は、図１３中の等化回路１２０の詳細構成を示す。図１３において、図３中の同一符号は、同一物、或いは、実質的に同一物を示す。

【０１３０】本第６実施形態では、ＭＭＳＥ方式のアダプティブアレーアンテナが、ＯＦＤＭ通信方式ではな

く、ＱＰＳＫ通信方式に適用されている。このため、アンテナ素子１１～１Ｍは、ＱＰＳＫ信号（パイロット信号）を受信する。

【０１３１】従って、アンテナ素子１１～１Ｍは、それぞれ、受信ＯＦＤＭ信号Ｘ（ｉ）に代えて、受信ＱＰＳＫ信号Ｘ（ｉ）を出力する。また、発生回路６０は、ＱＰＳＫ信号のパイロット信号r_0（ｉ）を所望既知信号として出力し、遅延回路９０は、ＱＰＳＫ信号のパイロット信号r_0（ｉ）に対して所望期間だけ遅延した遅延パイロット信号Ｒ（ｉ）を他の既知信号として出力する。ＭＭＳＥ演算器４０Ａは、上記第２実施形態と実質的に同様に、アンテナウエイトW"と信号ウエイトA"とを更新する。また、加算器（Σ）３０は、受信ＱＰＳＫ信号Ｘ（ｉ）のうち所望パイロット信号（所望既知信号）とその遅延パイロット信号（他の既知信号）との双方を除く成分が抑圧された信号を、内積信号W"Ｘとして出力する。また、等化回路１２０は、図１４に示すように、遅延器（Z^{-1}）１２１～１２４、乗算器１２５～１２８、及び、加算器１２９、１３０から構成されている。次に、本第６実施形態の等化回路１２０の作動について図１４、図１５を参照して説明する。

【０１３２】以下、図１５（ａ）に示すように、加算器（Σ）３０の内積信号W"Ｘとして、所望パイロット信号ＱＰ１と遅延パイロット信号ＱＰ２～ＱＰ５との総和が採用された例について説明する。

【０１３３】ここで、遅延パイロット信号ＱＰ２～ＱＰ５といった４つの遅延パイロット信号が採用されているため、本第６実施形態でのＭＭＳＥ演算器４０Ａの信号ウエイト（以下、信号ウエイトＡ（Ｇ）という）を、数式２７で表すことができる。Ｇは、サンプリングタイミング（更新タイミング）である（Ｇ＝ｔ１、ｔ２、ｔ３…）。また、図１５（ｂ）は、タイミングｔ１～ｔ５での遅延器１２１～１２４の出力を示す。

【０１３４】

【数２７】$A(G)=\left[a_1(G)\quad a_2(G)\quad a_3(G)\quad a_4(G)\right]^T$

先ず、タイミングｔ１にて、図１５（ａ）に示すＱＰＳＫシンボルＺＡが、加算器１３０を通して遅延器１２１に入力される。すなわち、等化回路１２０は、タイミングｔ１にて、ＱＰＳＫシンボルＺＡを出力できる。

【０１３５】次に、タイミングｔ２にて、図１５（ｂ）に示すように、遅延器１２１は、ＱＰＳＫシンボルＺＡを乗算器１２７に出力するとともに、ＱＰＳＫシンボルＺＡを遅延器１２２に出力する。すると、乗算器１２８は、信号ウエイトa_1（ｔ２）*をＱＰＳＫシンボルＺＡに乗算して乗算信号（a_1（ｔ２）*ＺＡ）を加算器１２９に出力する。

【０１３６】ここで、信号ウエイトa_1（ｔ２）*（信号ウエイトA"）は、上記第１実施形態で述べたように、ＭＭＳＥ演算器４０Ａによって、ＱＰＳＫシンボルＺＡ｛プリアンブル信号r_0（ｉ）｝を基準としたＱＰＳＫシンボルＺＡ１｛遅延信号Ｒ（ｉ）｝の位相差及び振幅差を示すように求められる。このため、乗算信号（a_1（ｔ２）*ＺＡ）は、ＱＰＳＫシンボルＺＡ１に等しくなる（ＺＡ１＝a_1（ｔ２）*ＺＡ）。

【０１３７】これにより、乗算器１２８は、乗算信号ＺＡ１を加算器１２９を通して加算器１３０に出力できる。また、加算器１３０には、加算器（Σ）３０の内積信号W"Ｘとして、ＱＰＳＫシンボルＺＢ、ＺＡ１が入力される。加算器１３０は、ＱＰＳＫシンボルＺＢ、ＺＡ１と乗算信号ＺＡ１との差を求めて差分信号（＝ＺＢ）を遅延器１２１に出力する。すなわち、等化回路１２０は、タイミングｔ２にて、ＱＰＳＫシンボルＺＢを出力できる。

【０１３８】次に、タイミングｔ３にて、遅延器１２２は、図１５（ｂ）に示すように、ＱＰＳＫシンボルＺＡを乗算器１２７に出力するとともに、ＱＰＳＫシンボルＺＡを遅延器１２３に出力する。すると、乗算器１２７は、信号ウエイトa_2（ｔ３）*をＱＰＳＫシンボルＺＡに乗算して乗算信号（a_2（ｔ３）*ＺＡ）を加算器１２９に出力する。

【０１３９】ここで、信号ウエイトa_2（ｔ３）*ＺＡ（信号ウエイトA"）は、上記第１実施形態で述べたように、ＭＭＳＥ演算器４０Ａによって、ＱＰＳＫシンボルＺＡ｛プリアンブル信号r_0（ｉ）｝を基準としたＱＰＳＫシンボルＺＡ２｛遅延信号Ｒ（ｉ）｝の位相差及び振幅差を示すように求められる。このため、乗算信号（a_2（ｔ３）*ＺＡ）は、ＱＰＳＫシンボルＺＡ２に等しくなる（ＺＡ２＝a_2（ｔ３）*ＺＡ）。従って、乗算器１２７は、ＱＰＳＫシンボルＺＡ２を加算器１２９に出力する。

【０１４０】また、遅延器１２１は、図１５（ｂ）に示すように、ＱＰＳＫシンボルＺＢを乗算器１２８に出力するとともに、ＱＰＳＫシンボルＺＢを遅延器１２２に出力する。乗算器１２８は、信号ウエイトa_1（ｔ３）*をＱＰＳＫシンボルＺＢに乗算して乗算信号（a_1（ｔ３）*ＺＢ）を加算器１２９に出力する。

【０１４１】ここで、信号ウエイトa_1（ｔ３）*（信号ウエイトA"）は、上記第１実施形態で述べたように、ＭＭＳＥ演算器４０Ａによって、ＱＰＳＫシンボルＺＢ｛プリアンブル信号r_0（ｉ）｝を基準としたＱＰＳＫシンボルＺＢ１｛遅延信号Ｒ（ｉ）｝の位相差及び振幅差を示すように求められる。

【０１４２】従って、乗算信号（a_1（ｔ３）*ＺＢ）は、ＱＰＳＫシンボルＺＢ１に等しくなる（ＺＢ１＝a_1（ｔ３）*ＺＢ）。従って、乗算器１２７は、乗算信号ＺＢ１を加算器１２９に出力できる。

【０１４３】ここで、加算器１２９は、乗算器１２７の乗算信号ＺＢ１と加算器１２９のＱＰＳＫシンボルＺＡ２とを加算して加算信号（ＺＢ１＋ＺＡ２）を加算器１

３０に出力する。加算器１３０には、加算器（Σ）３０の内積信号W"Ｘとして、ＱＰＳＫシンボルＺＣ、ＺＢ１、ＺＡ２が入力されて、加算器１３０は、ＱＰＳＫシンボルＺＣ、ＺＢ１、ＺＡ２と加算信号（ＺＢ１＋ＺＡ２）との差分を求め、差分信号ＺＣを遅延器１２１に出力する。

【０１４４】すなわち、等化回路１２０は、タイミングｔ３にて、ＱＰＳＫシンボルＺＣを出力できる。以下、等化回路１２０は、上述の作動と実質的に同様に作動して、タイミングｔ４にて、ＱＰＳＫシンボルＺＤを出力し、タイミングｔ５にて、ＱＰＳＫシンボルＺＥを出力する。

【０１４５】以上により、等化回路１２０は、上述の如く、ＱＰＳＫシンボルＺＡ～ＺＤだけを出力することができる。換言すれば、等化回路１２０は、加算器（Σ）３０の内積信号W"Ｘとして、所望パイロット信号ＱＰ１と遅延パイロット信号ＱＰ２～ＱＰ５との総和を入力されて、遅延パイロット信号ＱＰ２～ＱＰ５を抑圧して所望パイロット信号ＱＰ１だけを出力することになる。

【０１４６】なお、上記第６実施形態では、ＭＭＳＥ方式のアダプティブアレーアンテナをＱＰＳＫ通信方式に適用した例について説明したが、これに限らず、ＯＦＤＭ通信方式に適用してもよい。

【０１４７】さらに、本発明の実施にあたり、ＯＦＤＭ通信方式、ＣＤＭＡ通信方式、ＱＰＳＫ変調を用いた通信方式等以外に、各種通信方式を採用してもよい。

【０１４８】なお、第１～第６実施形態では、ＭＭＳＥ演算器４０Ａ、４０ＢでＭＭＳＥ方式のＳＭＩアルゴリズムを採用した例について説明したが、ＭＭＳＥ方式であれば、その他のアルゴリズムを採用してもよい。

【０１４９】（第７実施形態）ところで、上記第１実施形態にて述べたＭＭＳＥ方式のアダプティブアレーアンテナにおいては、所望信号と同一方向から干渉波が到来すると、その干渉波を抑圧できないという問題がある。すなわち、上記第１実施形態にて述べたＭＭＳＥ方式のアダプティブアレーアンテナでは、加算器３０の内積信号W"Ｘは、受信ＯＦＤＭ信号Ｘ（ｉ）のうちプリアンブル信号ｒ$_0$（ｉ）とその遅延信号Ｒ（ｉ）とを除く成分が抑圧された信号になるものの、プリアンブル信号ｒ$_0$（ｉ）と同一方向からＧＩ外遅延信号（干渉波）が到来すると、そのＧＩ遅延信号を抑制できないことになる。

【０１５０】従来のＰＩ方式のアダプティブアレーアンテナでは、到来波成分を、それに含まれる所望信号と干渉波とを区別することなく抑圧することは公知である。そこで、本第７実施形態において、従来のＰＩ方式のアダプティブアレーアンテナに着目して成されたもので、所望波及びＧＩ内遅延信号の双方の抑圧を防止し、かつ、所望信号と同一方向から到来する干渉波を抑圧して通信性能を向上させるようにする例につき説明する。この場合の構成を図１６に示す。

【０１５１】ＰＩ方式のアダプティブアレーアンテナは、アンテナ素子１１～１４、乗算器２１…２Ｍ、加算器（Σ）３０、ＰＩ演算器４１、加算器５１Ａ、乗算器５３Ａ及び、遅延回路８０Ａから構成されている。図１６において、図１中の符号と同一符号は、同一物、或いは、実質的同一物を示す。

【０１５２】遅延回路８０Ａは、上記第１実施形態で述べたプリアンブル信号ｒ$_0$（ｉ）を受けて、このプリアンブル信号ｒ$_0$（ｉ）と遅延信号Ｒ（ｉ）とを出力する。以下、遅延回路８０Ａの出力信号を出力信号Ｒ（ｉ）’という。

【０１５３】但し、プリアンブル信号に対する遅延信号Ｒ（ｉ）の遅延時間は、上述の如く、ＯＦＤＭシンボルのガードインターバルＧＩの期間ＴＧに比べて短く、遅延信号Ｒ（ｉ）の数（サンプルポイント数）を１６とする。

【０１５４】乗算器５３Ａは、信号ウエイトＡ"を出力信号Ｒ（ｉ）’に乗算して乗算信号｛Ａ"Ｒ（ｉ）’｝を求める。加算器５１Ａは、乗算信号｛Ａ"Ｒ（ｉ）’｝と加算器３０の内積信号W"Ｘ（ｉ）とを加算して加算参照信号（W"Ｘ（ｉ）＋Ａ"Ｒ（ｉ）’）を求める。

【０１５５】ＰＩ演算器４１には、加算参照信号（W"Ｘ（ｉ）＋Ａ"Ｒ（ｉ）’）、出力信号Ｒ（ｉ）’、及び、受信ＯＦＤＭ信号Ｘ（ｉ）が入力されて、ＰＩ演算器４１は、加算参照信号の電力｜W"Ｘ（ｉ）＋Ａ"Ｒ（ｉ）’｜^{2}を最小にするようにアンテナウエイトW及び信号ウエイトＡを更新する。このとき、信号ウエイトＡは、内積信号W"Ｘ（ｉ）に含まれる信号成分のうち、出力信号Ｒ（ｉ）’を打ち消すウエイトになり、アンテナウエイトWは、受信ＯＦＤＭ信号Ｘ（ｉ）に含まれる干渉波成分の電力を最小にするウエイトになる。

【０１５６】換言すれば、ＰＩ演算器４１は、加算参照信号の電力（W"Ｘ（ｉ）＋Ａ"Ｒ（ｉ）’）のうち、出力信号Ｒ（ｉ）’を除く成分の電力を最小にするようにアンテナウエイトW及び信号ウエイトＡを更新する。

【０１５７】図１７において、所望信号とＧＩ外遅延信号とが同一方向から到来したときのシュミレーションの結果を示す。図１７において、第１～第５波が到来したとき、ＰＩ方式のアダプティブアレーアンテナ、ＭＭＳＥ方式のアダプティブアレーアンテナの動作後の指向性を示す。右縦軸は、ＭＭＳＥ方式のアダプティブアレーアンテナを基準とした受信電波の受信角度［ｄｅｇ］、左縦軸は、ＰＩ方式のアダプティブアレーアンテナを基準とした受信電波の受信角度［ｄｅｇ］である。横軸は抑圧比（ｄＢ）である。

【０１５８】図１７において、ＭＭＳＥ方式のアダプティブアレーアンテナと、ＰＩ方式のアダプティブアレーアンテナとでは、アンテナゲインが異なるため、ＧＩ内

遅延信号がの方向のゲインが同じになるように表している。

【０１５９】ここで、鎖線は、ＭＭＳＥ方式のアダプティブアレーアンテナを用いたシュミレーションの結果を示す。実線は、ＰＩ方式のアダプティブアレーアンテナを用いたシュミレーションの結果を示す。図１７から分かるように、ＭＭＳＥ方式のアダプティブアレーアンテナでは、所望信号と同一方向のＧＩ外遅延信号が抑圧されていないが、ＰＩ方式のアダプティブアレーアンテナでは、所望信号と同一方向のＧＩ外遅延信号が抑圧されている。

【０１６０】（第８実施形態）本第８実施形態では、図１８に示すように、上記第７実施形態の示す構成に、ローパスフィルタ４２０～４２５が追加されている。図１８において、ローパスフィルタ４２０～４２４は、受信ＯＦＤＭ信号Ｘ（ｉ）に基づいて狭帯域のＯＦＤＭ信号信号を求める。

【０１６１】ローパスフィルタ４２０～４２４は、受信ＯＦＤＭ信号Ｘ（ｉ）のうちその所定周波数帯域の成分（図１９参照）だけを取り出すことにより、狭帯域ＯＦＤＭ信号信号を出力する。つまり、狭帯域のＯＦＤＭ信号信号は、受信ＯＦＤＭ信号Ｘ（ｉ）の周波数帯域を狭くした信号になる。

【０１６２】ローパスフィルタ４２５は、プリアンブル信号r_0（ｉ）に基づいて狭帯域プリアンブル信号を求める。つまり、ローパスフィルタ４２５は、プリアンブル信号r_0（ｉ）うちその所定周波数帯域の成分だけを取り出すことにより、狭帯域プリアンブル信号を出力する。

【０１６３】これに伴い、遅延回路８０Ａは、狭帯域プリアンブル信号に対して異なる遅延時間を有するＵ（図１９では、８）個の遅延信号を求め、この遅延信号と狭帯域プリアンブル信号との双方を出力信号Ｒ（ｉ）’として出力する。但し、プリアンブル信号に対する遅延信号の遅延時間は、上述の如く、ＯＦＤＭシンボルのガードインターバルＧＩの期間ＴＧに比べて短い。

【０１６４】ここで、出力信号Ｒ（ｉ）’のうち遅延信号の採用数（サンプルポイント）は、受信ＯＦＤＭ信号Ｘ（ｉ）の周波数帯域によって決まり、その周波数帯域を狭くすると、減らすことができる。

【０１６５】そこで、本第８実施形態のＰＩ演算器４１は、アンテナウエイトＷ及び信号ウエイトＡの更新にあたり、ＯＦＤＭ信号信号に代えて狭帯域ＯＦＤＭ信号信号を採用し、プリアンブル信号に基づいた出力信号Ｒ（ｉ）’に代えて、狭帯域プリアンブル信号に基づいた出力信号Ｒ（ｉ）’を採用する。このため、Ｒ（ｉ）の採用数を減らすことは勿論のこと、アンテナウエイトＷ及び信号ウエイトＡを更新回数を減らすことが可能になり、ウエイト更新の計算量を減らし得る。

【０１６６】（第９実施形態）上記第３実施形態では、ＯＦＤＭ信号のプリンアンブル信号を時間軸上の信号として採用したＭＭＳＥ方式のアダプティブアレーアンテナについて説明したが、本第９実施形態では、これに限らず、ＯＦＤＭ信号のプリンブル信号をＦＦＴ処理（周波数分別）した各弁別信号を採用したＰＩ方式のアダプティブアレーアンテナにつき説明する。この場合の構成を、図２０に示す。

【０１６７】ＰＩ方式のアダプティブアレーアンテナは、アンテナ素子１１～１４、乗算器２０１…２０４、加算器（Σ）３００、ＦＦＴ回路８０１～８０４、ＦＦＴ回路８３４、ＰＩ演算器４２、加算器５１０Ａ、乗算器５３０Ａ、及び、遅延回路８０Ａから構成されている。図２０において、図５中の符号と同一符号は、同一物を示す。

【０１６８】遅延回路８０Ａは、上記第８実施形態で述べた如く、プリアンブル信号r_0（ｉ）と遅延信号Ｒ（ｉ）とを併せて出力信号Ｒ（ｉ）’として出力する。ＦＦＴ回路８３４は、プリアンブル信号r_0（ｉ）と遅延信号Ｒ（ｉ）とのそれぞれの有効シンボルを並列的にサンプリング周期t_sでサンプリングしてそのサンプリング信号でＦＦＴ処理して弁別信号ＲＦＴ（ｉ）を出力する。

【０１６９】乗算器５３０Ａは、信号ウエイトＡ"を弁別信号ＲＦＴ（ｉ）に乗算して乗算信号｛Ａ"ＲＦＴ（ｉ）｝を求める。加算器５１０Ａは、乗算信号｛Ａ"ＲＦＴ（ｉ）｝と加算器３００の内積信号Ｗ"Ｘ（ｉ）’とを加算して加算参照信号（Ｗ"Ｘ（ｉ）’＋Ａ"ＲＦＴ（ｉ））を求める。

【０１７０】ＰＩ演算器４２には、弁別信号Ｘ（ｉ）’、加算参照信号（Ｗ"Ｘ（ｉ）’＋Ａ"ＲＦＴ（ｉ）’）、及び、弁別信号ＲＦＴ（ｉ）が入力されて、ＰＩ演算器４２は、加算参照信号の電力$|$Ｗ"Ｘ（ｉ）’＋Ａ"ＲＦＴ（ｉ）’$|^2$を最小にするようにアンテナウエイトＷ及び信号ウエイトＡを更新する。このとき、信号ウエイトＡは、内積信号Ｗ"Ｘ（ｉ）’に含まれる信号成分のうち、弁別信号ＲＦＴ（ｉ）を打ち消すウエイトになり、アンテナウエイトＷは、弁別信号Ｘ（ｉ）’に含まれる干渉波成分の電力を最小にするウエイトになる。

【０１７１】換言すれば、ＰＩ演算器４２は、加算参照信号（Ｗ"Ｘ（ｉ）’＋Ａ"ＲＦＴ（ｉ）’）のうち、弁別信号ＲＦＴ（ｉ）を除く成分の電力を最小にするようにアンテナウエイトＷ及び信号ウエイトＡを更新する。

（第１０実施形態）本第１０実施形態における、ＳＭＩ方式のアダプティブアレーアンテナは、図２１に示すように、アンテナ素子１１、１２、発生器６０、ＦＦＴ回路８３、８０１、８０２、乗算器２０１、２０２、加算器（Σ）３００、位相回転器１０００、相関器１０１０、選択回路１０２０、演算器１０３０から構成されている。

【０１７２】演算器１０３０は、相関行列推定器１０３１、逆行列演算器１０３２、相関ベクトル推定器１０３３、及び、行列乗算器１０３４を有する。なお、図２１において、図１、図２中の同一符号は、同一物を示す。

【０１７３】先ず、アンテナ素子１１で受信された受信ＯＦＤＭ信号x_1（ｉ）のプリンアンブル信号は、ＦＦＴ回路８０１でＦＦＴ処理されて、周波数毎に弁別信号$ft_1(1)$、$ft_1(2)$、$ft_1(3)$、$ft_1(4)$が求められる。また、アンテナ素子１２で受信された受信ＯＦＤＭ信号x_2（ｉ）は、ＦＦＴ回路８０２でＦＦＴ処理されて、周波数毎に弁別信号$ft_2(1)$、$ft_2(2)$、$ft_2(3)$、$ft_2(4)$が求められる。なお、弁別信号の括弧内の数字１…４は、ＦＦＴのポイント数を示す。

【０１７４】ここで、受信ＯＦＤＭ信号$x_1(i)$、$x_2(i)$、弁別信号$ft_1(1)$～$ft_1(3)$、及び弁別信号$ft_2(1)$～$ft_2(3)$を次のようにベクトル表記される。

【０１７５】

【数２８】$X(i)=[x_1(i)\quad x_2(i)]^T$

【０１７６】

【数２９】$FT_1(i)=[ft_1(1)\quad ft_1(2)\quad ft_1(3)]^T$

【０１７７】

【数３０】$FT_2(i)=[ft_2(1)\quad ft_2(2)\quad ft_2(3)]^T$

乗算器２０１は、アンテナウエイトw_1^*と$FT_1(i)$との行列積（$w_1^*FT_1(i)$）を求め、乗算器２０２は、アンテナウエイトw_2^*と$FT_2(i)$との行列積（$w_2^*FT_2(i)$）を求める。

【０１７８】次に、加算器（Σ）３００は、乗算器２０１、２０２による行列積（$w_1^*FT_1(i)$）、（$w_2^*FT_2(i)$）を、周波数毎に加算する。すなわち、行列積（$w_1^*FT_1(i)$）、（$w_2^*FT_2(i)$）、アンテナウエイトw_1^*、w_2^*を、数式３１、３２のようにベクトル表記すると、加算器（Σ）３００によって、アンテナウエイトＷと弁別信号Ｘ（ｉ）’との内積を示す内積信号$W^H X(i)'$が求められる。また、内積信号$W^H X(i)'$は、数式３３に示すようにベクトル表記される。

【０１７９】

【数３１】

$X(i)'=[FT_1(i)\quad FT_2(i)]^T$

【０１８０】

【数３２】$W=[w_1\quad w_2]^T$

【０１８１】

【数３３】$W^H X(i)'=[w_1^* ft_1(1)+w_2^* ft_2(1)\quad w_1^* ft_1(2)+w_2^* ft_2(2)\quad w_1^* ft_1(3)+w_2^* ft_2(3)]^T$

次に、発生器６０は、所望既知信号として、ＯＦＤＭ信号のプリアンブル信号$r_0(i)$を発生し、このプリアンブル信号$r_0(i)$は、周波数軸上に複数のパイロットシンボル（既知信号）が配列された信号である。また、ＦＦＴ回路８３は、ＯＦＤＭ信号のプリアンブル信号$r_0(i)$をＦＦＴ処理して周波数毎に所望弁別信号$rf_1(1)$、$rf_1(2)$、$rf_1(3)$を求める。

【０１８２】次に、位相回転器１０００は、所望弁別信号$rf_1(1)$を４種の位相量（０°θ°、２θ°　３θ°）だけ回転処理して、この回転処理された所望弁別信号$rf_1(1\ \theta)$、$rf_1(1\ 2\theta)$、$rf_1(1\ 3\theta)$と、所望弁別信号$rf_1(1)$とを出力する。

【０１８３】さらに、位相回転器１０００は、所望弁別信号$rf_1(2)$を４種の位相量（０°、θ°、２θ°、３θ°）だけ回転処理して、この回転処理された所望弁別信号$rf_1(2\ \theta)$、$rf_1(2\ 2\theta)$、$rf_1(2\ 3\theta)$と、所望弁別信号$rf_1(2)$とを出力する。

【０１８４】また、位相回転器１０００は、所望弁別信号$rf_1(3)$を４種の位相量（０°θ°、２θ°　３θ°）だけ回転処理して、この回転処理された所望弁別信号$rf_1(3\ \theta)$、$rf_1(3\ 2\theta)$、$rf_1(3\ 3\theta)$と、所望弁別信号$rf_1(3)$とを出力する。

【０１８５】ここで、所望弁別信号$rf_1(1)$～$rf_1(1\ 3\theta)$、$rf_1(2)$～$rf_1(2\ 3\theta)$、$rf_1(3)$～$rf_1(3\ 3\theta)$は、数式３４に示すように、求められる。

【０１８６】

【数３４】

$$BS=\begin{bmatrix} C_{11} & C_{12} & C_{13} \\ C_{21} & C_{22} & C_{23} \\ C_{31} & C_{32} & C_{33} \\ C_{41} & C_{42} & C_{43} \end{bmatrix}\begin{bmatrix} rf_1(1) & 0 & 0 \\ 0 & rf_1(2) & 0 \\ 0 & 0 & rf_1(3) \end{bmatrix}$$

【０１８７】但し、Ｃｔｆは、数式３５に示す位相量、ｔは位相量を示す番号、ｆは周波数を示す番号である。また、数式３５にて、$C_{11}=C_{12}=C_{13}$、$C_{21}=C_{22}=C_{23}$、$C_{31}=C_{32}=C_{33}$である。

【０１８８】

【数３５】$Ctf=\exp\{-2\pi j\cdot(j-1)\cdot(t-1)/3\}$

ここで、位相回転器１０００の出力信号は、図５に示すＦＦＴ回路８４の出力信号とＦＦＴ回路８３の出力信号とを併せたものと等価である。すなわち、ＦＦＴ回路８４は、位相回転器１０００とともに、プリアンブル信号$r_0(i)$に対してガードインターバル期間T_Gより短い遅延時間を生成し、この生成された遅延時間をＦＦＴ処理することと同等の役割を果たす。

【０１８９】次に、相関器１０１０は、所望処理信号ＢＳと弁別信号Ｘ（ｉ）’との相関値Ｋを求める。なお、

相関値Ｋは、所望処理信号ＢＳと弁別信号Ｘ（ｉ）’との行列積（ＢＳ×Ｘ（ｉ）’）により求められる。

【０１９０】選択回路１０２０は、相関値Ｋに基づいて、所望処理信号ＢＳのうち、弁別信号Ｘ（ｉ）’との相関が最も大きい所望処理信号BS_{max}を周波数毎に求める。

【０１９１】例えば、相関値Ｋを数式３６のようにベクトル表記する。数式３６中、相関値ｋｔｆにおいてｔは位相量を示す番号、ｆは周波数を示す番号である。

【０１９２】

【数３６】

$$K=\begin{bmatrix} K_{11} & K_{12} \\ K_{21} & K_{22} \\ K_{31} & K_{32} \\ K_{41} & K_{42} \end{bmatrix}$$

【０１９３】先ず、選択回路１０２０は、相関値ｋｔｆの各々の絶対値を求め、各々の絶対値の二乗値（$|ktf|^2$）を求めるとともに、絶対値の二乗値（$|ktf|^2$）を、各々、位相量毎に、加算して、数式３７に示す行列ＫＧを求める。

【０１９４】

【数３７】

$$KG=\begin{bmatrix} |K_{11}|^2+|K_{12}|^2 \\ |K_{21}|^2+|K_{22}|^2 \\ |K_{31}|^2+|K_{32}|^2 \\ |K_{41}|^2+|K_{42}|^2 \end{bmatrix}$$

【０１９５】次に、選択回路１０２０は、行列ＫＧのうち最大値を求めるとともに、行列ＢＳのうち、最大値の位相量に対応する所望弁別信号（以下、所望弁別信号$_{MX}$という）を周波数毎に求める。

【０１９６】ここで、所望弁別信号$rf_1(1)\cdots rf_1(2)\cdots rf_1(3\ \ 3\theta)$を示す行列ＢＳを数式３８の如くベクトル表記する。

【０１９７】

【数３８】

$$BS=\begin{bmatrix} rf_1(1) & rf_1(2) & rf_1(3) \\ rf_1(1\ \theta) & rf_1(2\ \theta) & rf_1(3\ \theta) \\ rf_1(1\ 2\theta) & rf_1(2\ 2\theta) & rf_1(3\ 2\theta) \\ rf_1(1\ 3\theta) & rf_1(2\ 3\theta) & rf_1(3\ 3\theta) \end{bmatrix}$$

【０１９８】例えば、行列ＫＧの最大値として、［$|k_{21}|^2+|k_{22}|^2$］が選択されたとき、数式３８のうち周波数毎の所望弁別信号ＭＸ（ｉ）として、［$rf_1(12\theta)\ \ rf_1(2\ \ 2\theta)$、$rf_1(3\ \ 2\theta)$］が選択される。さらに、数式３８のうち周波数毎の所望弁別信号ＭＸ（ｉ）以外の所望弁別信号を、数式３９に示す如く、所望処理信号ＢＡとする。但し、数式３９の所望処理信号ＢＡは、所望弁別信号ＭＸ（ｉ）として、［$rf_1(1\ \ 2\theta)\ \ rf_1(2\ \ 2\theta)$、$rf_1(3\ \ 2\theta)$］が選択された一例を示す。

【０１９９】

【数３９】

$$BA=\begin{bmatrix} rf_1(1) & rf_1(2) & rf_1(3) \\ rf_1(1\ \theta) & rf_1(2\ \theta) & rf_1(3\ \theta) \\ rf_1(1\ 3\theta) & rf_1(2\ 3\theta) & rf_1(3\ 3\theta) \end{bmatrix}$$

【０２００】なお、以下、説明を簡易に行うため、所望処理信号ＢＡ（ｉ）を、数式４０に示すようにベクトル表記し、所望弁別信号ＭＸ（ｉ）を数式４１に示すようにベクトル表記する。数式４０中、相関値ｂａｔｆにおいてｔは位相量を示す番号、ｆは周波数を示す番号である。数式４１中、ｍｘｔにおいて、ｔは位相量を示す番号である。

【０２０１】

【数４０】

$$BA(i)=\begin{bmatrix} ba_{11}(i) & ba_{21}(i) & ba_{31}(i) \\ ba_{12}(i) & ba_{22}(i) & ba_{32}(i) \\ ba_{13}(i) & ba_{23}(i) & ba_{33}(i) \end{bmatrix}$$

【０２０２】

【数４１】

$$MX(i)=\begin{bmatrix} mx_1 & mx_2 & mx_3 \end{bmatrix}$$

【０２０３】なお、以下、弁別信号Ｘ（ｉ）’を、数式４２に示す如くベクトル表記する。但し、数式４２におけるft_{MF}のＭは自然数でアンテナ素子の番号を示し、ｆは周波数を示す。

【０２０４】

【数４２】

$$X(i)'=\begin{bmatrix} ft_{11}(i) & ft_{12}(i) & ft_{13}(i) \\ ft_{21}(i) & ft_{22}(i) & ft_{23}(i) \end{bmatrix}$$

【０２０５】次に、相関行列推定器１０３１は、弁別信号Ｘ（ｉ）’と所望処理信号ＢＡとを併せて、数式４３に示す行列ＸＭを生成するとともに、数式４４、数式４５、数式４６により、行列ＸＭにおいて、個々の時刻での瞬時入力行列R_{XMXM1}、R_{XMXM2}、R_{XMXM3}を求める。数式４７に基づいて瞬時入力行列R_{XMXM1}、R_{XMXM2}、R_{XMXM3}を平均化して、相関行列の推定値R_{XMXM}を求める。

【０２０６】

【数４３】

$$XM(i)=\begin{bmatrix}X'(i)\\BA(i)\end{bmatrix}=\begin{bmatrix}ft_{11}(i) & ft_{12}(i) & ft_{13}(i)\\ft_{21}(i) & ft_{22}(i) & ft_{23}(i)\\ba_{11}(i) & ba_{21}(i) & ba_{31}(i)\\ba_{12}(i) & ba_{22}(i) & ba_{32}(i)\\ba_{13}(i) & ba_{23}(i) & ba_{33}(i)\end{bmatrix}$$

【0207】
【数44】$R_{xmxm1}=XM(1)\cdot XM(1)^H$
【0208】
【数45】$R_{xmxm2}=XM(2)\cdot XM(2)^H$
【0209】
【数46】$R_{xmxm3}=XM(3)\cdot XM(3)^H$
【0210】
【数47】
$R_{xmxm}=(R_{xmxm1}+R_{xmxm2}+R_{xmxm3})/3$
次に、逆行列演算器１０３２は、相関行列の推定値R_{xmxm}の逆行列R_{xmxm}^{-1}を求める。また、相関ベクトル推定器１０３３は、弁別信号Ｘ（ｉ）’、所望弁別信号ＭＸ、及び、所望弁別信号ＢＡを用いて、数式４８、数式４９、数式５０に示すように、個々の時刻における瞬時相関ベクトルr_{xmb1}、r_{xmb2}、r_{xmb3}を求める。
【0211】次に、相関ベクトル推定器１０３３は、数式５１に基づいて、瞬時相関ベクトルr_{xmb1}、r_{xmb2}、r_{xmb3}を周波数上で平均化して相関ベクトル推定値r_{xmb}を求める。
【0212】
【数48】$r_{xmb1}=XM(1)\cdot MX(1)^H$
【0213】
【数49】$r_{xmb2}=XM(2)\cdot MX(2)^H$
【0214】
【数50】$r_{xmb3}=XM(3)\cdot MX(3)^H$
【0215】
【数51】$r_{xmb}=(r_{xmb1}+r_{xmb2}+r_{xmb3})/3$
最後に、行列乗算器１０３４は、数式５２に示すように、相関行列の推定値R_{xmxm}と相関ベクトル推定値r_{xmb}とによって行列乗算して乗算結果Ｚを求めるとともに、乗算結果Ｚのうち「$w_1{}^*$ $w_2{}^*$」を乗算器２０１、２０２にそれぞれ出力する。なお、数式５１中、$-a_1$ $-a_2$ $-a_3$ $-a_4$は、上記第３実施形態に述べた信号ウエイトである。
【0216】
【数式52】
$Z=[w_1{}^*\ w_2{}^*\ -a_1\ -a_2\ -a_3\ -a_4]^T$
これにより、乗算器２０１、２０２は、行列積（$w_1{}^*FT_1(i)$）、行列積（$w_2{}^*FT_2(i)$）をそれぞれ求め、加算器（Σ）３００によって、行列積（$w_1{}^*FT_1(i)$）、（$w_2{}^*FT_2(i)$）が、周波数毎に加算されて、内積信号$W^H X(i)'$が求められる。
【0217】ここで、内積信号$W^H X(i)'$のうち、所望処理信号ＢＡと所望弁別信号ＭＸとを除く成分を抑圧するようにアンテナウエイトw_1、w_2が更新される。これにより、抑圧の必要の無い所望処理信号ＢＡと所望弁別信号ＭＸとの抑圧を防止して、上記第１、第２実施形態と実質的に同様に、本来、抑圧の必要の有る信号成分を抑圧できるので、ヌル点の形成を有効的に行うことができる。従って、ＳＭＩ方式のアダプティブアレーアンテナの自由度の無駄な消費を抑え得る。
【0218】例えば、図２２中αに示すように、アンテナ素子１１、１２によって、指向性を形成することができる。
【0219】すなわち、内積信号$W^H X(i)'$のうち所望弁別信号ＭＸは、抑圧されることなく、所望処理信号ＢＡ、ＭＸ以外のＧＩ外遅延信号は抑圧される。しかしながら、ＧＩ外遅延信号と所望処理信号ＢＡとが同一方向から受信されると、ＧＩ外遅延信号と所望処理信号ＢＡとは、共に抑圧される。このように、内積信号$W^H X(i)'$のうち、所望弁別信号ＭＸは、抑圧されることはなく残されるものの、所望処理信号ＢＡは、受信方向によっては抑圧されることがある。
【0220】さらに、アンテナウエイトw_1、w_2の更新によって、内積信号$W^H X(i)'$のうち、少なくとも所望弁別信号ＭＸの成分が残されて得られる。ここで、所望弁別信号ＭＸは、上述の如く、所望処理信号ＢＳのうち、弁別信号Ｘ（ｉ）’との相関が最も大きい信号であるため、所望弁別信号ＭＸの成分が残されることにより、弁別信号Ｘ（ｉ）’のうち受信レベルの大きな信号が、所望弁別信号ＭＸの成分として得ることができる。従って、所望弁別信号ＭＸの成分の復調を良好に行うことができる。
【0221】なお、上記第１１実施形態においては、ＦＦＴ回路８０１、８０２を採用してＳＭＩ方式のアダプティブアレアンテナを構成して、ＦＦＴ回路８０１、８０２は、それぞれ、受信ＯＦＤＭ信号$x_1(i)$をＦＦＴ処理し、このＦＦＴ処理された周波数軸上の信号に基づきアンテナウエイトw_1、w_2を求める例につき説明したが、これに限らず、以下のようにしてもよい。
【0222】すなわち、ＦＦＴ回路８０１、８０２を採用することなく、ＳＭＩ方式のアダプティブアレアンテナを構成して、受信ＯＦＤＭ信号$x_1(i)$をＦＦＴ処理した周波数軸上の信号に代えて、時間軸上の受信ＯＦＤＭ信号$x_1(i)$を採用して、時間軸上の受信ＯＦＤＭ信号$x_1(i)$アンテナウエイトw_1、w_2を求めるようにしてもよい。
（第１１実施形態）本第１１実施形態では、図２２に示

すように、上記第１０実施形態の示す構成に、ローパスフィルタ（ＬＰＦ）１０４０、１０４１が追加されている。

【０２２３】図２２において、ローパスフィルタ１０４０は、ＦＦＴ回路８０１からの弁別信号ft_1（１）～ft_1（３）に基づき狭帯域の弁別信号LF_1｛＝ft_1（１）、ft_1（２）｝を求める。これとともに、ローパスフィルタ１０４０は、ＦＦＴ回路８０２からの弁別信号ft_2（１）～ft_2（３）に基づき狭帯域の弁別信号LF_2｛＝ft_2（１）、ft_2（２）｝を求める。

【０２２４】これにより、ローパスフィルタ１０４０は、数式５３に示す狭帯域の弁別信号ＬＦを出力することになる。すなわち、ローパスフィルタ１０４０は、弁別信号ft_1（１）～ft_1（３）、ft_2（１）～ft_2（３）のうち、所定周波数帯域の成分だけを取り出すことにより、狭帯域の弁別信号LF_1、LF_2を出力する。

【０２２５】

【数５３】

$$LF=\begin{bmatrix} LF_1 \\ LF_2 \end{bmatrix}=\begin{bmatrix} ft_1(1) & ft_1(2) \\ ft_2(1) & ft_2(2) \end{bmatrix}$$

【０２２６】また、ローパスフィルタ１０４１は、ＦＦＴ回路８３及び位相回転器１０００の間に接続されて、ＦＦＴ回路８３からの所望弁別信号rf_1（１）、rf_1（２）、rf_1（３）に基づき狭帯域の弁別信号ｒＬＦ｛＝rf_1（１）、rf_1（２）｝を求める。すなわち、ローパスフィルタ１０４１は、所望弁別信号rf_1（１）、rf_1（２）、rf_1（３）のうち、所定周波数帯域の成分だけを取り出すことにより、狭帯域の弁別信号rf_1（１）、rf_1（２）を出力する。

【０２２７】次に、位相回転器１０００は、所望弁別信号rf_1（１）を４種の位相量（０°、θ°、２θ°、３θ°）だけ回転処理して、この回転処理された所望弁別信号rf_1（１　θ）、rf_1（１　２θ）、rf_1（１　３θ）と、所望弁別信号rf_1（１）とを出力する。

【０２２８】さらに、位相回転器１０００は、所望弁別信号rf_1（２）を４種の位相量（０°、θ°、２θ°、３θ°）だけ回転処理して、この回転処理された所望弁別信号rf_1（２　θ）、rf_1（２　２θ）、rf_1（２　３θ）と、所望弁別信号rf_1（２）とを出力する。

【０２２９】なお、以下、所望弁別信号rf_1（１）～rf_1（１　３θ）、rf_1（２）～rf_1（２　３θ）を、数式５４に示すように、所望処理信号ＬＢＳとする。

【０２３０】

【数５４】

$$LBS=\begin{bmatrix} rf_1(1) & rf_1(2) \\ rf_1(1\ \theta) & rf_1(2\ \theta) \\ rf_1(1\ 2\theta) & rf_1(2\ 2\theta) \\ rf_1(1\ 3\theta) & rf_1(2\ 3\theta) \end{bmatrix}$$

【０２３１】次に、本第１１実施形態の相関器１０１０は、上記第１０実施形態で述べた所望処理信号ＢＳに代わる所望処理信号ＬＢＳと、弁別信号Ｘ（ｉ）’に代わる狭帯域の弁別信号ｒＬＦとの相関値Ｋ’を求める。また、選択回路１０２０は、上記第１０実施形態と実質的同様に、相関値Ｋ’に基づいて、所望処理信号ＬＢＳのうち、狭帯域の弁別信号ｒＬＦとの相関が最も大きい周波数毎の所望弁別信号ＭＸ’を求める。さらに、所望処理信号ＬＢＳのうち、所望処理信号ＭＸ’以外の所望処理信号ＢＡ’を求める。

【０２３２】次に、演算器１０３０では、弁別信号Ｘ（ｉ）’に代えて狭帯域の弁別信号ｒＬＦが入力されて、所望処理信号ＭＸに代えて所望処理信号ＭＸ’が入力されるとともに、所望処理信号ＢＡに代えて所望処理信号ＢＡ’が入力される。

【０２３３】そこで、相関行列推定器１０３１は、相関ベクトル推定器１０３３及び逆行列演算器１０３２とともに、上記第１０実施形態と実質的同様に、狭帯域の弁別信号ｒＬＦと所望処理信号ＭＸ’とに基づいて相関行列の推定値R_{xMxM}を求めるとともに、相関行列の推定値R_{xMxM}の逆行列R_{xMxM}^{-1}を求める。

【０２３４】また、相関ベクトル推定器１０３３は、上記第１０実施形態と実質的同様に、狭帯域の弁別信号ｒＬＦ、所望弁別信号ＭＸ’、及び、所望弁別信号ＢＡ’を用いて、相関ベクトル推定値r_{xMb}を求める。さらに、行列乗算器１０３４によって、相関行列の推定値R_{xMxM}と相関ベクトル推定値r_{xMb}とが行列乗算されてアンテナウエイトw_1 w_2が求められて乗算器２０１、２０２にそれぞれ出力される。

【０２３５】以上により、内積信号W"Ｘ（ｉ）’のうち、所望処理信号ＢＡと所望弁別信号ＭＸとを除く成分が抑圧されるため、上記第１０実施形態と実質的に同様の効果が得られる。さらに、内積信号W"Ｘ（ｉ）’のうち、少なくとも所望弁別信号ＭＸ’の成分が残されて得られるため、上記第１０実施形態と実質的同様に、所望弁別信号ＭＸの成分の復調を良好に行うことができる。

【０２３６】また、相関器１０１０の相関値の演算にあたり、所望処理信号ＢＳに代えて所望処理信号ＬＢＳが採用されるとともに、弁別信号Ｘ（ｉ）’に代えて狭帯域の弁別信号ｒＬＦが採用される。ここで、所望処理信号ＬＢＳは、上述の如く、所望処理信号ＢＳに比べて周波数領域が狭く、狭帯域の弁別信号ｒＬＦは、上述の如く、弁別信号Ｘ（ｉ）’に比べて周波数領域が狭い。こ

のため、相関器１０１０の相関値の演算量を、上記第１０実施形態に比べて、減らすことができる。

【０２３７】さらに、選択回路１０２０が所望処理信号MX’BA’を求めるにあたり、相関器１０１０の相関値K’と、所望処理信号ＬＢＳと、狭帯域の弁別信号ｒＬＦとを採用するので、選択回路１０２０の演算量を、上記第１０実施形態に比べて、減らすことができる。

【０２３８】また、演算器１０３０がアンテナウエイトw_1 w_2を求めるにあたり、弁別信号Ｘ（ｉ）’に代えて狭帯域の弁別信号ｒＬＦが採用されるとともに、所望処理信号MXに代えて所望処理信号MX’が採用される。このため、演算器１０３０の演算量を、上記第１０実施形態に比べて、減らすことができる。

（第１２実施形態）本第１２実施形態では、上記第１１実施形態で述べたローパスフィルタ（ＬＰＦ）１０４０、１０４１を採用して、ＰＩ方式のアダプティブアレーアンテナを構成する例につき説明する。この場合の構成を、図２３に示す。

【０２３９】本第１２実施形態における、ＰＩ方式のアダプティブアレーアンテナは、アンテナ素子１１、１２、発生器６０、ＦＦＴ回路８３、８０１、８０２、乗算器２０１、２０２、加算器（Σ）３００、位相回転器１０００、ローパスフィルタ（ＬＰＦ）１０４０、１０４１、演算器１０３０Ａから構成されている。演算器１０３０Ａは、相関行列推定器１０３１Ａ、逆行列演算器１０３２Ａ、行列乗算器１０３４Ａを有する。なお、図２３において、図１、図２、図２２中の同一符号は、同一物を示す。

【０２４０】先ず、ローパスフィルタ１０４０は、上記第１１実施形態と同様に、ＦＦＴ回路８０１からの弁別信号ft_1（１）〜ft_1（３）に基づき狭帯域の弁別信号LF_1｛＝ft_1（１）、ft_1（２）｝を求めるとともに、ＦＦＴ回路８０２からの弁別信号ft_2（１）〜ft_2（３）に基づき狭帯域の弁別信号LF_2｛＝ft_2（１）、ft_2（２）｝を求める。

【０２４１】次に、位相回転器１０００は、上記第１１実施形態と同様に、ローパスフィルタ１０４１からの狭帯域の弁別信号ｒＬＦ｛＝rf_1（１）、rf_1（２）｝に基づいて、数式５３に示す所望処理信号ＬＢＳを求める。

【０２４２】次に、演算器１０３０Ａおいて相関行列推定器１０３１Ａは、狭帯域の弁別信号LF_1、LF_2と所望処理信号ＬＢＳとを併せて、数式５５に示す行列ＦＢを生成するとともに、上記第１０実施形態と実質的同様に、行列ＦＢにおける、相関行列の推定値R_{FBFB}を求める。

【０２４３】

【数５５】

$$FB=\begin{bmatrix} LF_1 \\ LF_2 \\ LBS \end{bmatrix}=\begin{bmatrix} ft_1(1) & ft_1(2) \\ ft_2(1) & ft_2(2) \\ rf_1(1) & rf_1(2) \\ rf_1(1\ \theta) & rf_1(2\ \theta) \\ rf_1(1\ 2\theta) & rf_1(2\ 2\theta) \\ rf_1(1\ 3\theta) & rf_1(2\ 3\theta) \end{bmatrix}$$

【０２４４】次に、逆行列演算器１０３２Ａは、相関行列の推定値R_{FBFB}の逆行列R_{FBFB}^{-1}を求める。さらに、行列乗算器１０３４Ａは、数式５６に示す式を用いて、乗算結果Ｚ’を求めるとともに、乗算結果Ｚ’のうち、アンテナウエイトw_1 w_2を乗算器２０１、２０２にそれぞれ出力する。なお、数式５５中、$-a_1$ $-a_2$ $-a_3$ $-a_4$は、上記第９実施形態に述べた信号ウエイトＡ"である。

【０２４５】ここで、アンテナウエイトw_1 w_2は、加算回路３００の内積信号W"Ｘ（ｉ）’のうち、所望処理信号ＬＢＳを除く成分の電力を最小にするように更新される。

【０２４６】

【数５６】

$$\begin{aligned} Z' &= [1\ \ 0\ \ 0\ \ 0]^T\times R_{FBFB}^{-1} \\ &= [w_1^*\ w_2^*\ -a_1\ \ -a_2\ \ -a_3\ \ -a_4]^T \end{aligned}$$

さらに、演算器１０３０Ａは、アンテナウエイトw_1 w_2を求めるにあたり、狭帯域の弁別信号ｒＬＦが採用されるとともに、所望処理信号ＬＢＳが採用される。ここで、狭帯域の弁別信号ｒＬＦの周波数帯域は、上記第１０実施形態で述べた弁別信号Ｘ（ｉ）’の周波数帯域に比べて狭く、所望処理信号ＬＢＳの周波数帯域は、上記第１０実施形態で述べた所望処理信号ＢＳの周波数帯域に比べて、狭い。従って、演算器１０３０Ａは、弁別信号Ｘ（ｉ）’と所望処理信号ＢＳとを用いたときに比べて、演算量を減らすことができる。

【０２４７】なお、本発明の実施にあたり、アンテナ素子の数としては、２個以上であれば、幾らでもよい。

【０２４８】さらに、上記各実施形態では、各種信号を周波数弁別するにあたり、ＦＦＴ処理を採用した例について説明したが、これに限らず、ＤＦＴ処理等の各種の周波数弁別処理を採用してもよい。

【図面の簡単な説明】

【図１】本発明の第１実施形態のMMＳＥ方式のアダプティブアレーアンテナの構成を示す図である。

【図２】上記第１実施形態のMMＳＥ方式のアダプティブアレーアンテナのシュミレーションの結果を示す図である。

【図３】本発明の第２実施形態のMMＳＥ方式のアダプティブアレーアンテナの構成を示す図である。

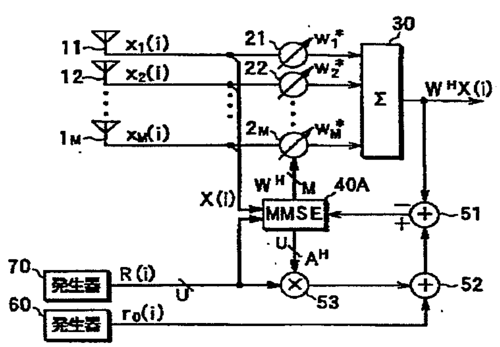
【図４】図３に示す遅延回路の詳細構成を示す図である。

【図５】本発明の第３実施形態のMMＳＥ方式のアダプ

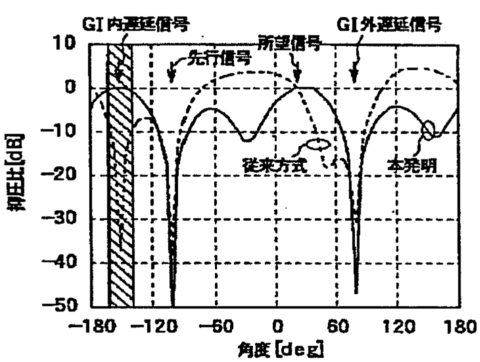
ティブアレーアンテナの構成を示す図である。
【図６】図５に示すＦＦＴ回路の詳細構成を示す図である。
【図７】図５に示す遅延回路の作動を示す図である。
【図８】図６に示すＦＦＴ回路の作動を示す図である。
【図９】本発明の第４実施形態のMMＳＥ方式のアダプティブアレーアンテナの構成を示す図である。
【図１０】図９に示すマッチドフィルタ及び遅延回路の作動を示す図である。
【図１１】本発明の第５実施形態のMMＳＥ方式のアダプティブアレーアンテナの構成を示す図である。
【図１２】図１１に示す所望信号選択回路の詳細構成を示す図である。
【図１３】本発明の第６実施形態のMMＳＥ方式のアダプティブアレーアンテナの構成を示す図である。
【図１４】図１３に示す等価回路の詳細構成を示す図である。
【図１５】図１４に示す等価回路の作動を示す図である。
【図１６】本発明の第７実施形態のＰＩ方式のアダプティブアレーアンテナの構成を示す図である。
【図１７】上記第７実施形態のＰＩ方式のアダプティブアレーアンテナのシュミレーションの結果を示す図であ＊

＊る。
【図１８】本発明の第８実施形態のＰＩ方式のアダプティブアレーアンテナの構成を示す図である。
【図１９】図１８のＬＰＦの作動を示す図である。
【図２０】本発明の第９実施形態のＰＩ方式のアダプティブアレーアンテナの構成を示す図である。
【図２１】本発明の第１０実施形態のＳＭＩ方式のアダプティブアレーアンテナの構成を示す図である。
【図２２】上記第１０実施形態の作動を説明するための図である。
【図２３】本発明の第１１実施形態のＳＭＩ方式のアダプティブアレーアンテナの構成を示す図である。
【図２４】本発明の第１１実施形態のＰＩ方式のアダプティブアレーアンテナの構成を示す図である。
【図２５】ＯＦＤM信号のフォーマットを示す図である。
【図２６】MMＳＥ方式のアダプティブアレーアンテナの受信信号を説明するための図である。
【図２７】従来のMMＳＥ方式のアダプティブアレーアンテナの構成を示す図である。
【符号の説明】
４０Ａ…MMＳＥ演算器、３０、５１、５２…加算器、６０、７０…発生器。

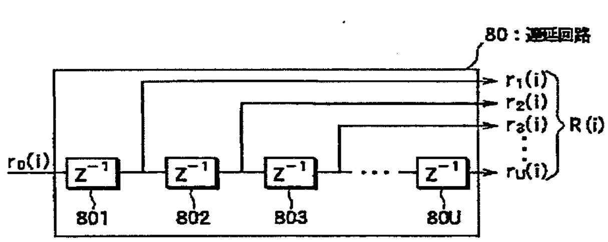
【図１】



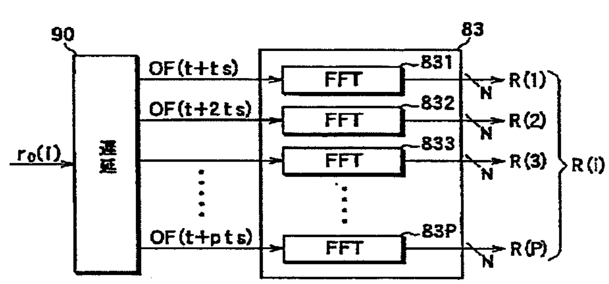
【図２】



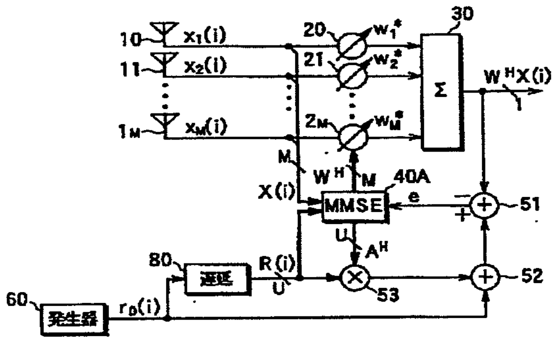
【図４】



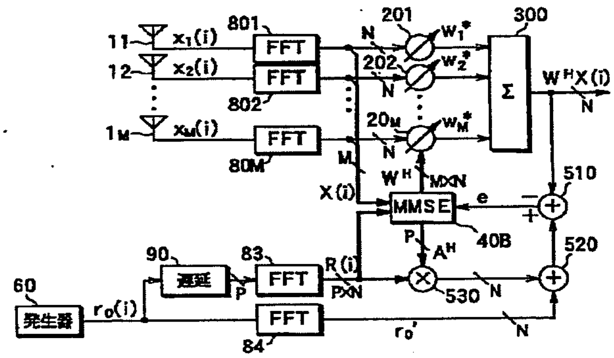
【図６】



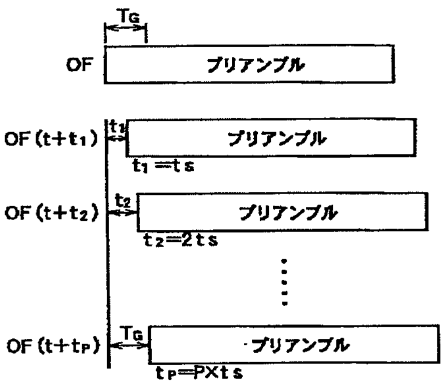
【図３】



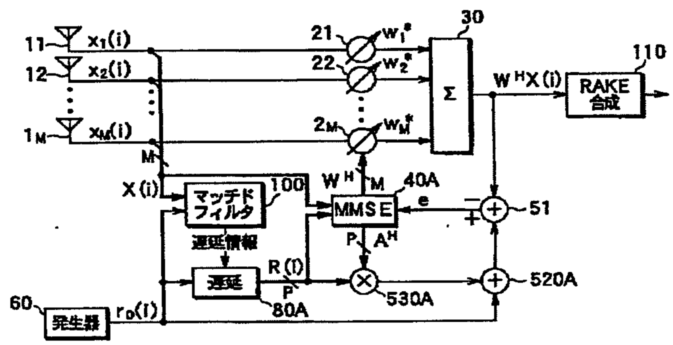
【図５】



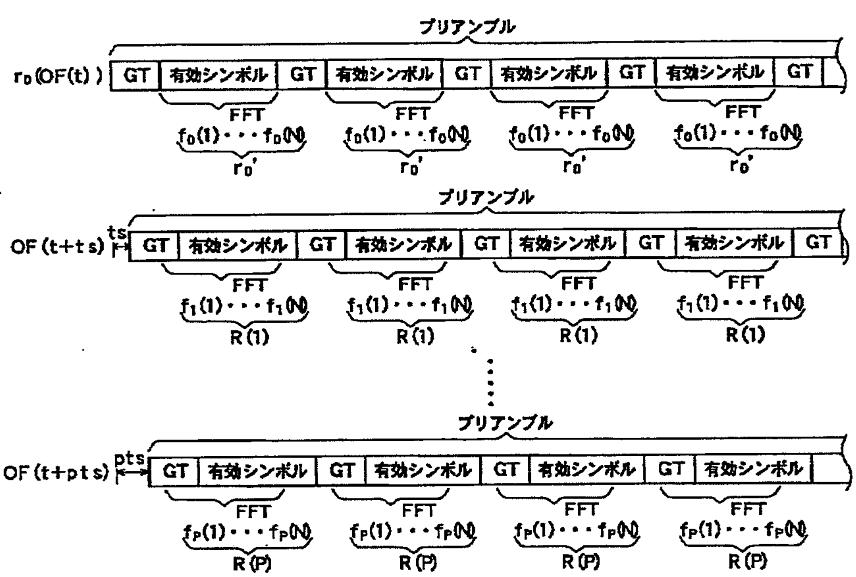
【図７】



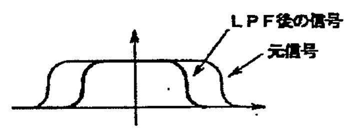
【図９】



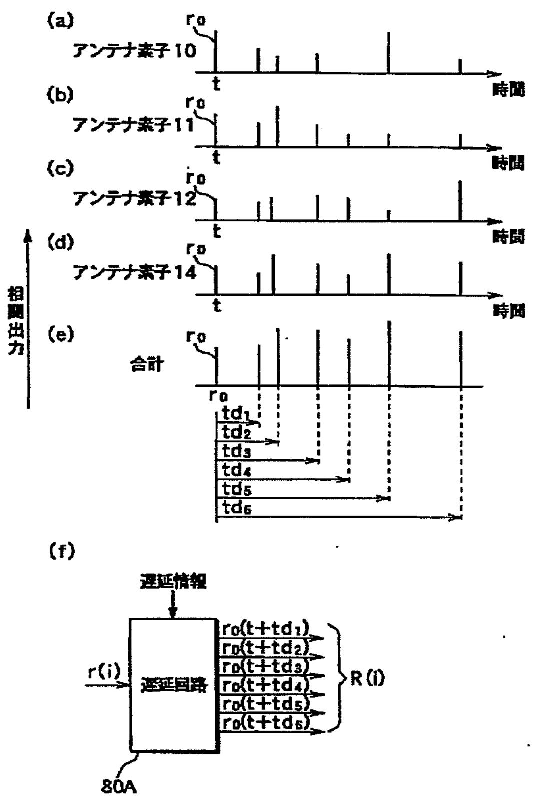
【図８】



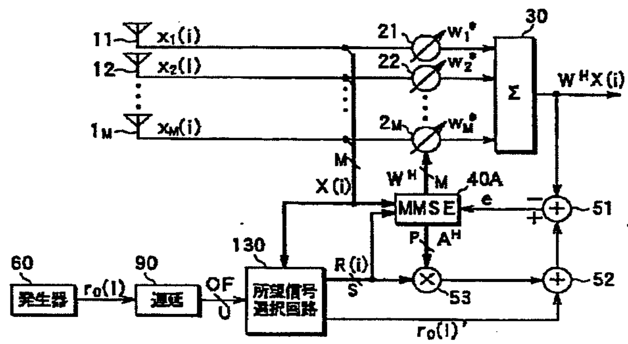
【図１９】



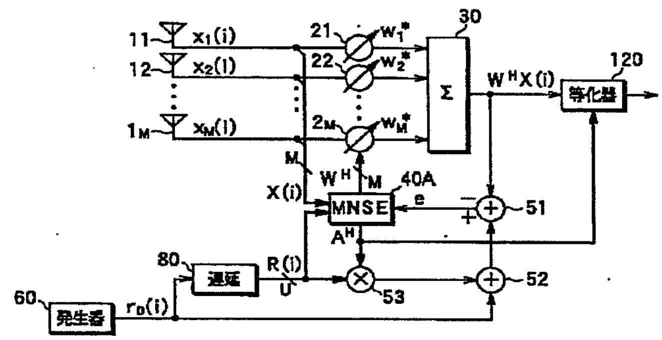
【図１０】



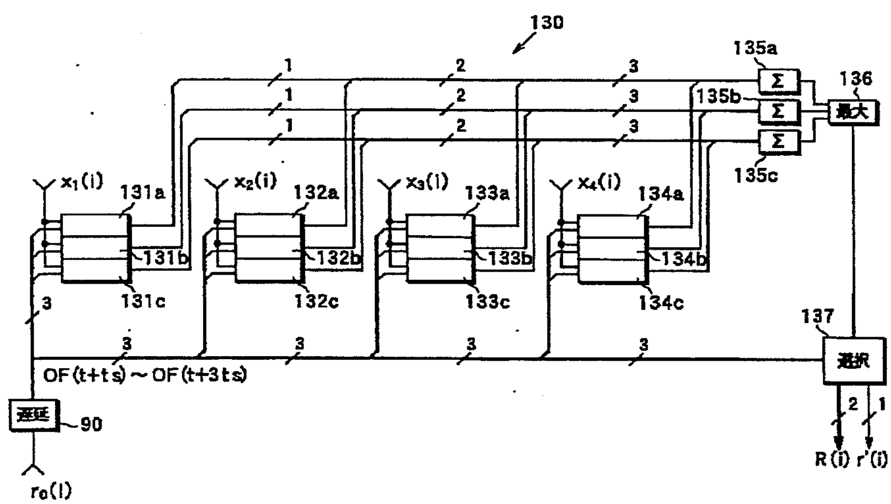
【図１１】



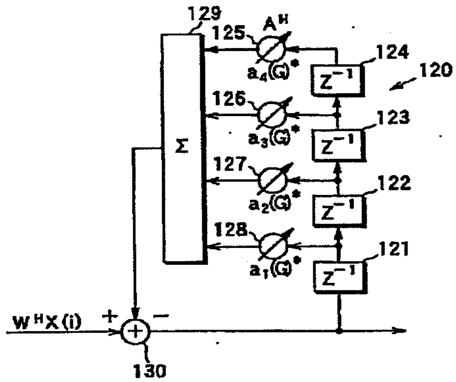
【図１３】



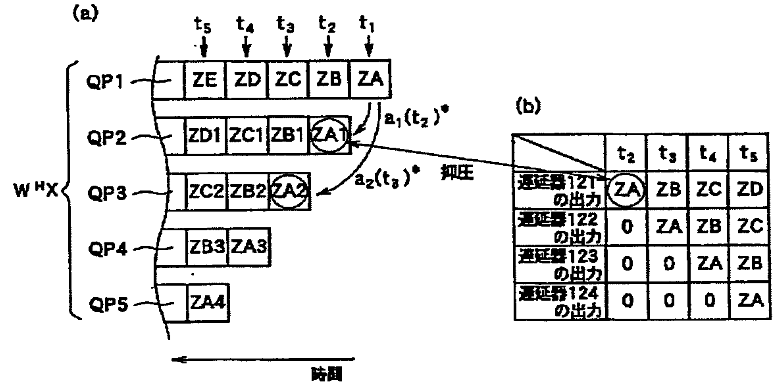
【図１２】



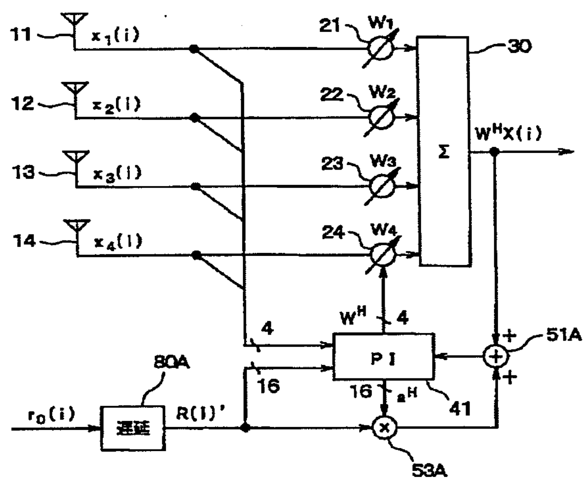
【図１４】



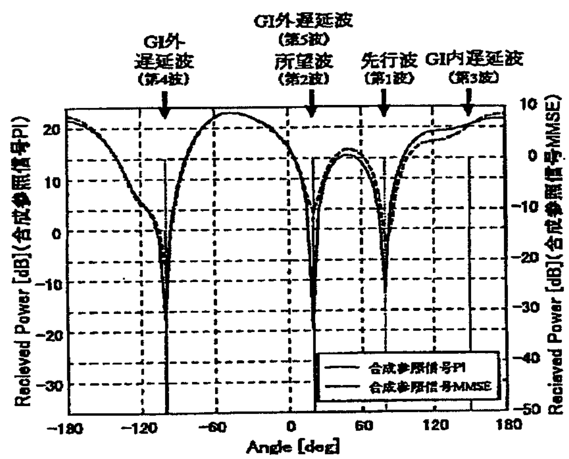
【図１５】



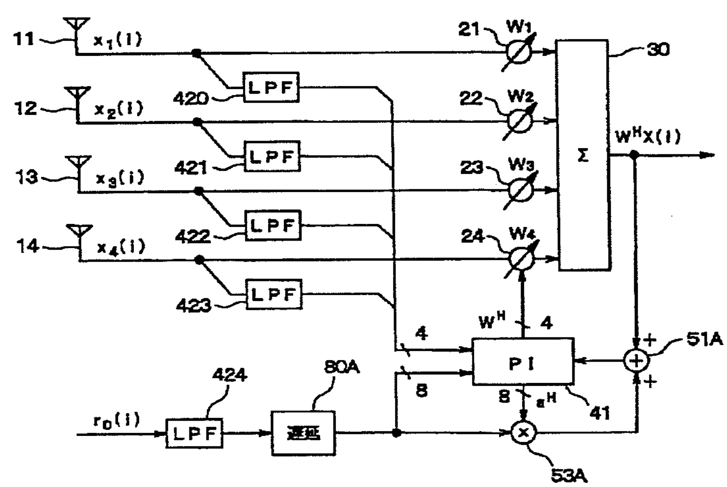
【図１６】



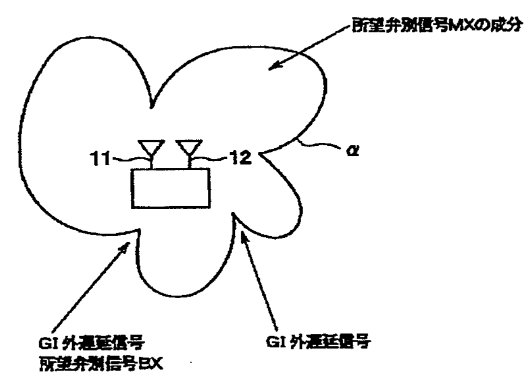
【図１７】



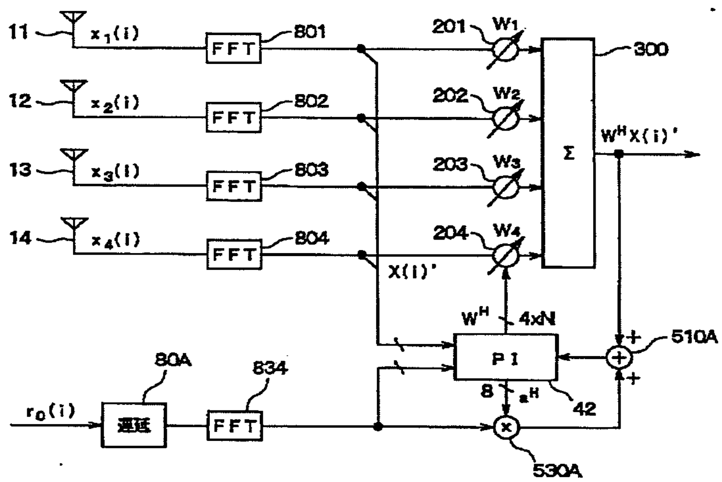
【図１８】



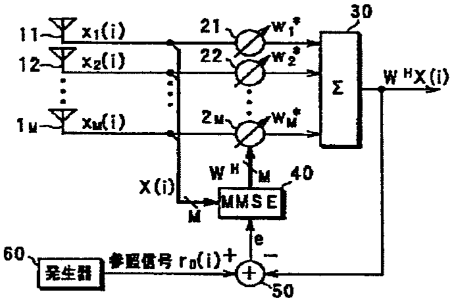
【図２２】



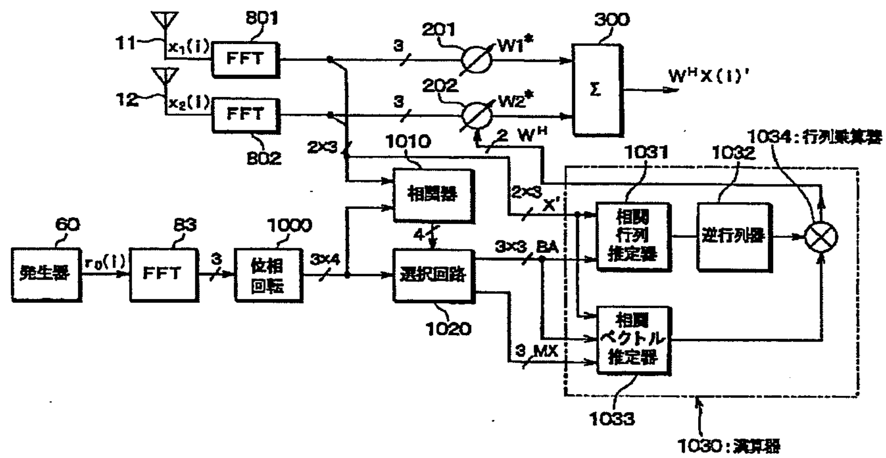
【図２０】



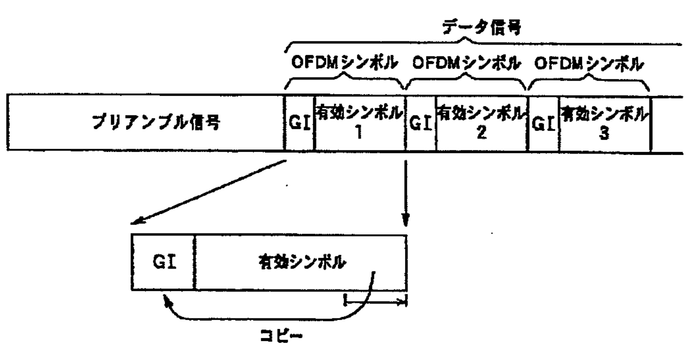
【図２７】



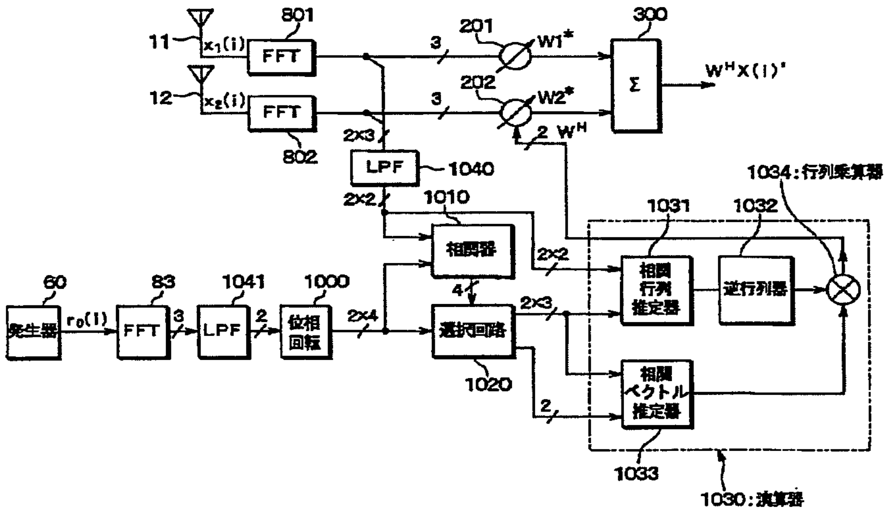
【図２１】



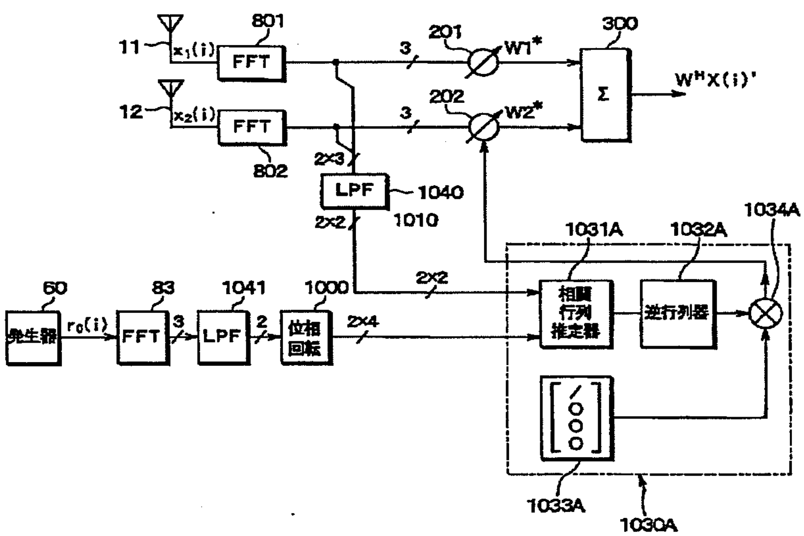
【図２５】



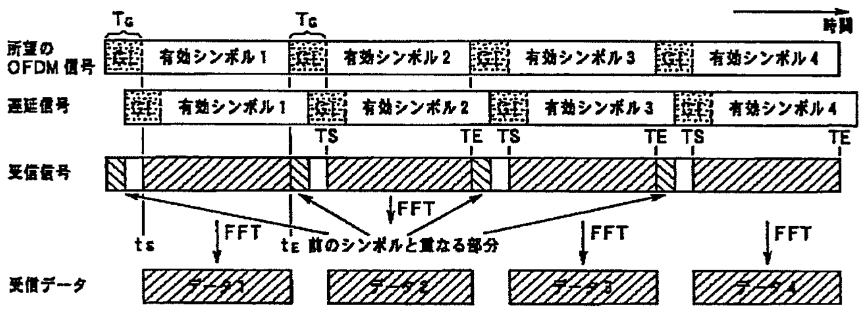
【図２３】


11
12
801
802
FFT
FFT
$x_1(i)$
$x_2(i)$
201
202
W1*
W2*
300
Σ
$W^H X(i)'$
2×3
LPF
1040
2×2
1010
相関器
2 W^H
1034:行列乗算器
1031
1032
相関行列推定器
逆行列器
60
83
1041
1000
発生器
$r_0(i)$
FFT
LPF
位相回転
2×4
選択回路
1020
2×3
相関ベクトル推定器
1033
1030:演算器

【図２４】


11
12
801
802
FFT
FFT
$x_1(i)$
$x_2(i)$
201
202
W1*
W2*
300
Σ
$W^H X(i)'$
2×3
LPF
1040
2×2
1010
1034A
1031A
1032A
相関行列推定器
逆行列器
60
83
1041
1000
発生器
$r_0(i)$
FFT
LPF
位相回転
2×4
1033A
1030A

【図２６】



フロントページの続き

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④

JAPANESE [JP,2002-359513,A]

CLAIMS DETAILED DESCRIPTION TECHNICAL FIELD PRIOR ART TECHNICAL PROBLEM MEANS DESCRIPTION OF DRAWINGS DRAWINGS

[Translation done.]

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CLAIMS

[Claim(s)]
[Claim 1] The antenna multiplication means which carries out the multiplication of each antenna weight to the input signal received by two or more antenna elements (11 -- 1M) and said two or more antenna elements (21 -- 2M), An addition means by which said antenna weight adds each input signal by which multiplication was carried out, and outputs an addition signal (30), A reference-sign calculation means to ask for a reference sign from the 1st known signal and the 2nd known signal (51-53, 51A, 53A), The adaptive array antenna characterized by having an updating means (40A, 41) to update said antenna weight according to the input signal received by said two or more antenna elements, said addition signal, and said reference sign.
[Claim 2] Said 2nd known signal is an adaptive array antenna according to claim 1 characterized by being the delay signal which carried out predetermined period delay to said 1st known signal.
[Claim 3] The adaptive array antenna according to claim 2 characterized by having said delay means (80) to carry out predetermined period delay and to search for said 2nd known signal for said 1st known signal.
[Claim 4] Said two or more antenna elements receive the signal which has the component of said 1st known signal, and the component of said 2nd known signal as said input signal, respectively. Based on the input signal received by said two or more antenna elements, it has a time delay calculation means (100) to find the time delay of the component of the 2nd [to the component of said 1st known signal / said] known signal. Said delay means is an adaptive array antenna according to claim 2 characterized by only for said time delay delaying said request known signal, and searching for said 2nd known signal.
[Claim 5] A delay signal generation means by which only time amount which is different to said 1st known signal, respectively generates two or more delay signals for ******** (90), The correlating detector which performs correlation detection of said two or more delay signals and said input signal (131a-134c), The adaptive array antenna according to claim 2 characterized by having a selection means (135a-136) to choose any of two or more of said delay signals they are as said 2nd known signal based on the correlation detection of said correlating detector.
[Claim 6] Said reference-sign calculation means is equipped with the weight multiplication section (53) which carries out the multiplication of the signal weight to said 2nd known signal. This signal weight adds said 1st known signal to said 2nd known signal by which multiplication was carried out, and it asks for said reference sign. Said updating means It is the adaptive array antenna of any one publication among claims 1-5 characterized by updating said signal weight according to the input signal received by said two or more antenna elements, the 2nd [said] known signal, said reference sign, and said addition signal.
[Claim 7] An oppression means to add a return signal in order to oppress the component of said 2nd known signal among the addition signals of said addition means (129 130), An addition signal delay means only for a predetermined period to delay said addition signal and to generate a delay addition signal (121-124), The adaptive array antenna according to claim 6 characterized by having a multiplication means (125-128) to carry out the multiplication of said signal weight to said delay addition signal, and to ask for said return signal.
[Claim 8] A received frequency discrimination means to carry out frequency discrimination of the

receiving OFDM signal received by two or more antenna elements (11 — 1M) and said two or more antenna elements, respectively, and to search for a discrimination signal (801-80M), The antenna multiplication means which carries out the multiplication of the antenna weight to said each discrimination signal by which frequency discrimination was carried out (201-20M), An addition means by which said antenna weight adds each discrimination signal by which multiplication was carried out, and outputs an addition signal (300), A request frequency judgment means to search for the request discrimination signal with which frequency discrimination of the request OFDM signal was carried out (84), A delay means to search for the delayed discrimination signal delayed to said request discrimination signal (90 83), A reference addition means to add said request discrimination signal to said delayed discrimination signal with which the multiplication of the signal weight was carried out to said delayed discrimination signal, and the multiplication of this signal weight was carried out, and to ask for a reference sign (510, 520, 530), According to each of said discrimination signal and said delayed discrimination signal, said addition signal is brought close to said reference sign. The adaptive array antenna characterized by having an updating means (40B) to update said antenna weight and said signal weight so that the component except the both sides of said request discrimination signal and a delayed discrimination signal may be oppressed among said each discrimination signal.
[Claim 9] A received frequency discrimination means to carry out frequency discrimination of the receiving OFDM signal received by two or more antenna elements (11-14) and said two or more antenna elements, respectively, and to search for a discrimination signal (801-804), The antenna multiplication means which carries out the multiplication of the antenna weight to said each discrimination signal by which frequency discrimination was carried out (201-204), An addition means by which said antenna weight adds each discrimination signal by which multiplication was carried out, and outputs an addition signal (300), A delay means to search for the delay OFDM signal which carried out predetermined period delay to the request OFDM signal (80A), A request frequency judgment means by which the both sides of said request OFDM signal and said delay OFDM signal search for the request discrimination signal by which frequency discrimination was carried out (834), A reference addition means to carry out the multiplication of the signal weight to said request discrimination signal, and to ask for a reference sign (530A), An addition reference-sign calculation means to add said reference sign and said addition signal, and to ask for an addition reference sign (510A), The adaptive array antenna characterized by having an updating means (42) to update said antenna weight and said signal weight so that power of the component except the component of said request discrimination signal may be made small among said addition reference signs.
[Claim 10] The adaptive array antenna according to claim 8 or 9 characterized by having a generation means (60) to generate the preamble signal with which the known signal was arranged on the frequency shaft as said request OFDM signal.
[Claim 11] It is the adaptive array antenna according to claim 10 which said received frequency discrimination means carries out the thump rig of said receiving OFDM signal, acquires each sampling signal, searches for said discrimination signal according to said each sampling signal, and is characterized by said time delay being the predetermined multiple of the period of said sampling.
[Claim 12] Said delay means is the adaptive array antenna of any one publication of claim 8-11 characterized by outputting said delayed discrimination signal of the request number.
[Claim 13] The request number of said delayed discrimination signal is an adaptive array antenna according to claim 12 characterized by the guard interval period of the data signal of said request OFDM signal, the period of said sampling, and being the maximum number it is decided be alike.
[Claim 14] A means for said reference-sign calculation means to carry out the multiplication of the signal weight to said 1st and 2nd known signals, and to ask for said reference sign (53A), It has a means (51A) to add said reference sign and said addition signal, and to ask for an addition reference sign. Said updating means (41) The adaptive array antenna according to claim 2 or 3 characterized by updating said antenna weight and said signal weight so that power of the component except said 1st and 2nd known signals may be made small among said addition

reference signs.
[Claim 15] The antenna multiplication means which carries out the multiplication of each antenna weight to the input signal received by two or more antenna elements (11-14) and said two or more antenna elements (21--24), An addition means by which said antenna weight adds each input signal by which multiplication was carried out, and outputs an addition signal (30), A received signalling frequency output means to output the received signalling frequency which shows the component of a narrow frequency band compared with the frequency band of these input signals among the input signals received by said two or more antenna elements, respectively (420-423), A known signalling frequency output means to output the known signalling frequency which shows the component of said narrow frequency band among known signals (424), A delay means to search for the delay signalling frequency which carried out predetermined period delay to said known signalling frequency (80A), A reference-sign calculation means to carry out the multiplication of the signal weight to said delay signalling frequency and said known signalling frequency, and to ask for a reference sign (53A), An addition reference-sign calculation means to add said reference sign and said addition signal, and to ask for an addition reference sign (51A), The adaptive array antenna characterized by having an updating means (41) to update said antenna weight and said signal weight so that power of the component except said delay signalling frequency and said known signalling frequency may be made small among said addition reference signs.
[Claim 16] A received frequency discrimination means to carry out frequency discrimination of the receiving OFDM signal received by two or more antenna elements (11 12) and said two or more antenna elements, respectively, and to search for a discrimination signal (801 802), The antenna multiplication means which carries out the multiplication of the antenna weight to said each discrimination signal by which frequency discrimination was carried out (201 202), An addition means by which said antenna weight adds each discrimination signal by which multiplication was carried out, and outputs an addition signal (300), A known frequency judgment means to carry out frequency discrimination of the known OFDM signal, and to search for a known discrimination signal (83), A phase revolution means only for each amount of phases to carry out a phase revolution to said known discrimination signal, and to search for the phase revolution known discrimination signal corresponding to said each amount of phases (1000), A correlation means to take correlation with the phase revolution known discrimination signal corresponding to said each amount of phases, and said each discrimination signal, and to calculate the correlation value corresponding to said each amount of phases (1010), While choosing a maximum correlation value among the correlation values corresponding to said each amount of phases the phase revolution known discrimination signal corresponding to said each amount of phases -- with a selection means (1020) to choose the response phase revolution known discrimination signal corresponding to said maximum correlation value inside While making small the component except the phase revolution known discrimination signal corresponding to said each amount of phases among said addition signals The adaptive array antenna characterized by having an updating means (1034) to update said antenna weight so that it may leave said response phase revolution known discrimination signal at least among said addition signals.
[Claim 17] A received frequency discrimination means to carry out frequency discrimination of the receiving OFDM signal received by two or more antenna elements (11 12) and said two or more antenna elements, respectively, and to search for a discrimination signal (801 802), The antenna multiplication means which carries out the multiplication of the antenna weight to said each discrimination signal by which frequency discrimination was carried out (201 202), An addition means by which said antenna weight adds each discrimination signal by which multiplication was carried out, and outputs an addition signal (300), A narrow-band output means to output the narrow-band discrimination signal of a narrow frequency band among said each discrimination signal compared with said discrimination signal, respectively (1040), A request frequency judgment means to carry out frequency discrimination of the known OFDM signal, and to search for a known discrimination signal (83), A known narrow-band output means to output the narrow-band known discrimination signal of a narrow frequency band among said known

discrimination signals compared with said known discrimination signal (1041), Only the amount of phases which is different to said narrow-band known discrimination signal, respectively carries out a phase revolution. A phase revolution means to search for the signal according to phase rotary valve of the narrow-band corresponding to said each amount of phases (1000), A correlation means to take correlation with the signal according to phase rotary valve of the narrow-band corresponding to said each amount of phases, and said each discrimination signal, and to calculate the correlation value corresponding to said each amount of phases (1010), While choosing a maximum correlation value among the correlation values corresponding to said each amount of phases A selection means to choose the signal according to phase rotary valve of the narrow-band corresponding to said maximum correlation value among the signals according to phase rotary valve of each of said narrow-band (1020), While making small the component except the phase revolution known discrimination signal of the narrow-band corresponding to said each amount of phases among said addition signals The adaptive array antenna characterized by having an updating means (1033) to update said antenna weight so that it may leave the signal according to phase rotary valve of said corresponding narrow-band at least among said addition signals.

[Claim 18] A received frequency discrimination means to carry out frequency discrimination of the receiving OFDM signal received by two or more antenna elements (11 12) and said two or more antenna elements, respectively, and to search for a discrimination signal (801 802), The antenna multiplication means which carries out the multiplication of the antenna weight to said each discrimination signal by which frequency discrimination was carried out (201 202), An addition means by which said antenna weight adds each discrimination signal by which multiplication was carried out, and outputs an addition signal (300), A narrow-band output means to output the narrow-band discrimination signal of a narrow frequency band among said each discrimination signal compared with said discrimination signal, respectively (1040), A request frequency judgment means to carry out frequency discrimination of the known OFDM signal, and to search for a known discrimination signal (83), A known narrow-band output means to output the narrow-band known discrimination signal of a narrow frequency band among said known discrimination signals compared with said known discrimination signal (1041), The phase revolution means which carries out the phase revolution of said narrow-band known discrimination signal (1000), The adaptive array antenna characterized by having an updating means (1030A) to update said antenna weight so that power of the component except said narrow-band known discrimination signal and said narrow-band known discrimination signal by which the phase revolution was carried out may be made small among said addition signals.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to an adaptive array antenna.
[0002]
[Description of the Prior Art] In recent years, the various proposals of the adaptive array antenna of the MMSE method which receives the input signal of a rectangular cross multi-carrier method are made. First, the outline of the signal (the signal of a rectangular cross multi-carrier method is hereafter called OFDM signal) of a rectangular cross multi-carrier method is explained with reference to drawing 25 and drawing 26 .
[0003] As shown in drawing 25 , the OFDM signal consists of a data signal and a preamble signal before this data signal. A preamble signal is a signal which arranged two or more pilot symbols (known signal) on the frequency shaft. A data signal consists of two or more OFDM symbols by which time multipled was carried out, and an OFDM symbol consists of a guard interval GI before an effective symbol and this effective symbol.
[0004] the guard interval GI -- an effective symbol -- the predetermined period part on [inner] the backside is copied. Therefore, if the time delay of the delay signal over a desired OFDM signal is shorter than the period TG of the guard interval GI when the sum of a desired OFDM signal and a desired delay signal is received as an input signal as shown in drawing 26 , data (for example, QPSK symbol) can restore an input signal by FFT processing (frequency discrimination processing).
[0005] Next, the adaptive array antenna of an MMSE (Minimum Mean Square Error) method is explained with reference to drawing 23 . Drawing 27 shows the outline configuration of the adaptive array antenna of an MMSE method. The adaptive array antenna of an MMSE method is an antenna element 11. -- They are 1M and a multiplier 21. -- It consists of 2M, the adder (sigma) 30, an MMSE computing element 40, an adder 50, and a generator 60. In addition, M is the natural number.
[0006] Antenna element 11 -- 1M receive an OFDM signal through an electric wave, and output the receiving OFDM signal X (i), respectively. Here, the receiving OFDM signal X (i) can be expressed with a formula 1. T shows transposition. i shows time of day.
[0007]
[Equation 1]
X(i) =[-- x1(i) x2(i) -- [ ] -- xM (i) --] -- T -- this sake -- antenna element 11 --1M -- respectively -- the receiving OFDM signal x1 (i), x2 (i), and -- xM (i) is outputted. Moreover, the MMSE computing elements 50 are multipliers 21 and 22. -- Multiplication is carried out to each of 2M at the antenna weight WH.
[0008] Here, the antenna weight WH can be expressed with a formula 2. H is complex-conjugate transposition.
[0009]
[Equation 2] A multiplier 20 carries out the multiplication of the receiving OFDM signal x1 (i) to antenna weight w1*, and outputs a multiplication signal (w1*x1(i)), and a multiplier 21 carries out the multiplication of the receiving OFDM signal x2 (i) to antenna weight w2*, and outputs a

multiplication signal (w2*x2 (i)) to a W=[w1 w2 -- wM] T concrete target. Multiplier 2M carry out the multiplication of the receiving OFDM signal XM (i) to antenna weight wM*, and output a multiplication signal (wM*xM (i)).
[0010] An adder (sigma) 30 is a multiplication signal (w1*x1(i)) and a multiplication signal (w2*x2 (i)). -- The inner product signal WHX (i) which shows the inner product of the antenna weight W and the receiving OFDM signal X (i) is searched for by adding a multiplication signal (wM*xM (i)). a generator 60 memorizes a reference sign r0 (i) beforehand, and outputs this reference sign r0 (i) to an adder 50, and an adder 50 asks for error [of a reference sign r0 (i) and the inner product signal WHX (i)] e (i) -- {-- e(i) =r0(i)- WHX (i) --} . The MMSE computing element 40 updates the antenna weight W so that this error e (i) may be made small by considering the receiving OFDM signal X (i) and error e (i) as an input, and it is multipliers 21 and 22 about that antenna weight W. -- It outputs to 2M.
[0011] Here, the delay signal except a request known signal etc. can be oppressed among the receiving OFDM signals X (i) by adopting a request known signal (for example, preamble signal on a time-axis) as a reference sign r0 (i). Incidentally, in the adaptive array antenna of an MMSE method, the number of the known signals (null point) which can be oppressed is prescribed by the number of antenna elements, and it is (the number of antenna elements). - It is "1." Hereafter, the number of the known signals (null point) which can be oppressed is called degree of freedom.
[0012]
[Problem(s) to be Solved by the Invention] By the way, in the adaptive array antenna of an MMSE method, although the time delay of the delay signal over a request known signal can restore data (the data 1 in drawing 26 - data 4) from an input signal if it is shorter than the period TG of the guard interval GI when the sum of a request known signal and its delay signal is received as an input signal like ****, the delay signal (henceforth the delay signal in GI) concerned will be oppressed.
[0013] It becomes impossible thus, to compound two or more signals and to raise the receiving engine performance by there being no need of oppressing and oppressing the delay signal in GI which can be restored and compounded.
[0014] moreover, null [in / in order to oppress the delay signal in GI / an adaptive array antenna] -- the delay signal delayed for the delay signal in GI since a point would be formed -- like -- original -- null -- the signal which should form a point -- null -- there is a problem of it becoming impossible to form a point. That is, the degree of freedom of an adaptive array antenna will be consumed vainly.
[0015] This invention aims at offering the adaptive array antenna which held down useless consumption of a degree of freedom in view of the above.
[0016]
[Means for Solving the Problem] In order to attain the above-mentioned object, this invention in invention according to claim 1 The antenna multiplication means which carries out the multiplication of each antenna weight to the input signal received by two or more antenna elements (11 -- 1M) and two or more antenna elements (21 -- 2M), An addition means by which antenna weight adds each input signal by which multiplication was carried out, and outputs an addition signal (30), A reference calculation means to ask for a reference sign from the 1st known signal and the 2nd known signal (51-53, 51A, 53A), It is characterized by having an updating means (40A, 41) to update antenna weight according to the input signal, reference sign, and addition signal which were received by two or more antenna elements.
[0017] Here, a reference sign is computed from the 1st and 2nd known signals, and an updating means updates antenna weight according to a reference sign and the above-mentioned input signal concerned, the 2nd known signal, and an addition signal. For this reason, an updating means can oppress the component except the 1st and 2nd known signals by renewal of antenna weight among the input signals received by two or more antenna elements. Therefore, since oppression of the 2nd known signal is prevented and a signal component with the need for oppression can originally be oppressed when oppression of the 2nd known signal is unnecessary, the Nur point can be formed in an effective target. For this reason, useless consumption of the

degree of freedom of an adaptive array antenna is held down.
[0018] Moreover, since the component except the 2nd known signal is oppressed among [1st] input signals, the composite signal of the 1st and 2nd known signals can be acquired among input signals. Here, like invention according to claim 2, the 2nd known signal can acquire a good recovery signal, when it is the delay signal which carried out predetermined period delay to said 1st known signal and gets over using the composite signal of the 1st and 2nd known signals compared with the case where it restores only to the 1st known signal.
[0019] Furthermore, you may make it have a delay means (80) to carry out predetermined period delay of the 1st known signal, and to search for the 2nd known signal like invention according to claim 3. Moreover, the 2nd known signal is not prepared beforehand but you may make it search for the 2nd known signal according to an input signal.
[0020] Like invention according to claim 4, namely, two or more antenna elements The signal which has the component of the 1st known signal and the component of the 2nd known signal is received as an input signal, respectively. Based on the input signal received by two or more antenna elements, it has a time delay calculation means (100) to find the time delay of the component of the 2nd [to the component of the 1st known signal] known signal, and only a time delay delays a request known signal and you may make it a delay means search for the 2nd known signal.
[0021] Furthermore, a delay signal generation means by which only time amount which is different to the 1st known signal, respectively generates two or more delay signals for ******** like invention according to claim 5 (90), You may make it have the correlating detector (131a-134c) which performs correlation detection of each delay signal of a delay signal generation means, and said input signal, and a selection means (135a-136) to choose any of two or more delay signals they are as 2nd known signal based on the correlation detection of a correlating detector.
[0022] Like invention according to claim 6, specifically a reference-sign calculation means The 1st known signal is added to the 2nd known signal with which the multiplication of the signal weight was carried out to the 2nd known signal, and the multiplication of this signal weight was carried out, and it asks for a reference sign. An updating means You may make it update signal weight according to the input signal and the 2nd known signal which were received by two or more antenna elements, a reference sign, and an addition signal.
[0023] An oppression means to add a return signal by invention according to claim 7 here in order to oppress the component of the known signal of [2nd] the addition signals of an addition means (129 130), It is characterized by having an addition signal delay means (121-124) only for a predetermined period to delay an addition signal and to generate a delay addition signal, and a multiplication means (125-128) to carry out the multiplication of said signal weight to a delay addition signal, and to ask for said return signal. Thereby, an oppression means oppresses the component of the 2nd known signal among addition signals, and can output only the component of the 1st known signal.
[0024] Two or more antenna elements [invention / according to claim 8] (11 -- 1M), A received frequency discrimination means to carry out frequency discrimination of the receiving OFDM signal received by two or more antenna elements, respectively, and to search for a discrimination signal (801-80M), The antenna multiplication means which carries out the multiplication of the antenna weight to each discrimination signal by which frequency discrimination was carried out (201-20M), An addition means by which antenna weight adds each discrimination signal by which multiplication was carried out, and outputs an addition signal (300), A request frequency judgment means to search for the request discrimination signal with which frequency discrimination of the request OFDM signal was carried out (84), A delay means to search for the delayed discrimination signal delayed to the request discrimination signal (90 83), A reference addition means to add a request discrimination signal to the delayed discrimination signal with which the multiplication of the signal weight was carried out to the delayed discrimination signal, and the multiplication of this signal weight was carried out, and to ask for a reference sign (510, 520, 530), According to each of said discrimination signal and said delayed discrimination signal, said addition signal is brought close to said reference sign. It is characterized by having an

updating means (40B) to update said antenna weight and said signal weight so that the component except the both sides of said request discrimination signal and a delayed discrimination signal may be oppressed among said each discrimination signal.

[0025] Thus, an updating means updates antenna weight and signal weight so that the component except the both sides of a request discrimination signal and a delayed discrimination signal may be oppressed among each discrimination signal. For this reason, since oppression of a delayed discrimination signal is prevented and a signal component with the need for oppression can originally be oppressed when oppression of a delayed discrimination signal is unnecessary, the Nur point can be formed in an effective target. For this reason, useless consumption of the degree of freedom of an adaptive array antenna is held down.

[0026] Moreover, since an updating means updates antenna weight and signal weight so that the component except the both sides of a request discrimination signal and a delayed discrimination signal may be oppressed among each discrimination signal like ****, it can obtain the both sides of a request discrimination signal and a delayed discrimination signal among each discrimination signal. If it gets over using the both sides of such a request discrimination signal and a delayed discrimination signal, a good recovery signal will be acquired compared with the case where it gets over only by the request discrimination signal.

[0027] Two or more antenna elements [invention / according to claim 9] (11-14), A received frequency discrimination means to carry out frequency discrimination of the receiving OFDM signal received by said two or more antenna elements, respectively, and to search for a discrimination signal (801-804), The antenna multiplication means which carries out the multiplication of the antenna weight to said each discrimination signal by which frequency discrimination was carried out (201-204), An addition means by which said antenna weight adds each discrimination signal by which multiplication was carried out, and outputs an addition signal (300), A delay means to search for the delay OFDM signal which carried out predetermined period delay to the request OFDM signal (80A), A request frequency judgment means by which the both sides of said request OFDM signal and said delay OFDM signal search for the request discrimination signal by which frequency discrimination was carried out (834), A reference addition means to carry out the multiplication of the signal weight to said request discrimination signal, and to ask for a reference sign (530A), An addition reference-sign calculation means to add said reference sign and said addition signal, and to ask for an addition reference sign (510A), It is characterized by having an updating means (42) to update said antenna weight and said signal weight so that power of the component except said request discrimination signal may be made small among said addition reference signs.

[0028] Thus, since an updating means updates antenna weight and signal weight so that power of the component except the component of request discrimination ****** may be made small among addition reference signs, it can make small power of the component except the component of a request discrimination signal among addition reference signs. Therefore, while oppression of the signal with which oppression of a request discrimination signal is prevented, namely, frequency discrimination of the request OFDM signal was carried out is prevented, oppression of the signal with which frequency discrimination of the delay OFDM signal was carried out is prevented.

[0029] For this reason, since a signal component with the need for oppression can originally be oppressed when oppression of the signal with which frequency discrimination of the delay OFDM signal was carried out is unnecessary, the Nur point can be formed in an effective target. For this reason, useless consumption of the degree of freedom of an adaptive array antenna is held down.

[0030] Moreover, you may make it have a generation means (60) to generate the preamble signal with which the known signal was arranged on the frequency shaft as said request OFDM signal like invention according to claim 10. Furthermore, like invention according to claim 11, a received frequency discrimination means may carry out the thump rig of the receiving OFDM signal, each sampling signal may be acquired, said discrimination signal may be searched for according to each sampling signal, and you may make it a time delay be the predetermined multiple of the period of a sampling.

[0031] Furthermore, in invention according to claim 12, a delay means is characterized by outputting one delayed discrimination signal and said delayed discrimination signal of the request number. Thereby, like invention according to claim 1, an updating means can update said each antenna weight and signal weight so that the component except said request discrimination signal and the delayed discrimination signal of the request number may be oppressed among said each discrimination signal.
[0032] Furthermore, in invention according to claim 13, the request number of a delayed discrimination signal is characterized by being the maximum number decided by the guard interval period of the data signal of a request OFDM signal, and the period of a sampling. Thereby, further, since oppression of many delayed discrimination signals can be prevented, useless consumption of the degree of freedom of an adaptive array antenna can be held down effectively. In addition, the maximum number of a delayed discrimination signal is {(period of a guard interval period / sampling) −1}.
[0033] In invention according to claim 14, a reference-sign calculation means A means to carry out the multiplication of the signal weight to said 1st and 2nd known signals, and to ask for said reference sign (53A), It has a means (51A) to add said reference sign and said addition signal, and to ask for an addition reference sign. Said updating means (41) It is characterized by updating said antenna weight and said signal weight so that power of the component except said 1st and 2nd known signals may be made small among said addition reference signs.
[0034] Thus, since an updating means (41) updates antenna weight and signal weight so that power of the component except the 1st and 2nd known signals may be made small among addition reference signs, it can make small power of the component except the 1st and 2nd known signals among addition reference signs. For this reason, control of the 1st and 2nd known signals can be prevented, and since a signal component with the need for oppression can originally be oppressed when control of the 2nd known signal is unnecessary, the Nur point can be formed in an effective target.
[0035] Two or more antenna elements [invention / according to claim 15] (11-14), The antenna multiplication means which carries out the multiplication of each antenna weight to the input signal received by said two or more antenna elements (21--24), An addition means by which said antenna weight adds each input signal by which multiplication was carried out, and outputs an addition signal (30), A received signalling frequency output means to output the received signalling frequency which shows the component of a narrow frequency band compared with the frequency band of these input signals among the input signals received by said two or more antenna elements, respectively (420-423), A known signalling frequency output means to output the known signalling frequency which shows the component of said narrow frequency band among known signals (424), A delay means to search for the delay signalling frequency which carried out predetermined period delay to said known signalling frequency (80A), A reference-sign calculation means to carry out the multiplication of the signal weight to said delay signalling frequency and said known signalling frequency, and to ask for a reference sign (53A), An addition reference-sign calculation means to add said reference sign and said addition signal, and to ask for an addition reference sign (51A), It is characterized by having an updating means (41) to update said antenna weight and said signal weight so that power of the component except said delay signalling frequency and said known signalling frequency may be made small among said addition reference signs.
[0036] Thus, since an updating means updates antenna weight and signal weight so that power of the component except delay signalling frequency and known signalling frequency may be made small among addition reference signs, it can make small power of the component except delay signalling frequency and known signalling frequency among addition reference signs. For this reason, control of delay signalling frequency and known signalling frequency can be prevented, and since a signal component with the need for oppression can originally be oppressed when control of delay signalling frequency is unnecessary, the Nur point can be formed in an effective target.
[0037] Here, the count of updating of antenna weight and signal weight is decided by the frequency band of an input signal, and since it replaces with an input signal in renewal of antenna

weight and signal weight and the known signalling frequency of a narrow frequency band is used for it like **** compared with the frequency band of an input signal, it can reduce the count of updating of antenna weight and signal weight.
[0038] Moreover, two or more antenna elements [invention / according to claim 16] (11 12), A received frequency discrimination means to carry out frequency discrimination of the receiving OFDM signal received by two or more antenna elements, respectively, and to search for a discrimination signal (801 802), The antenna multiplication means which carries out the multiplication of the antenna weight to each discrimination signal by which frequency discrimination was carried out (201 202), An addition means by which antenna weight adds each discrimination signal by which multiplication was carried out, and outputs an addition signal (300), A known frequency judgment means to carry out frequency discrimination of the known OFDM signal, and to search for a known discrimination signal (83), A phase revolution means only for each amount of phases to carry out a phase revolution to a known discrimination signal, and to search for the phase revolution known discrimination signal corresponding to each amount of phases (1000), A correlation means to take correlation with the phase revolution known discrimination signal corresponding to each amount of phases, and each discrimination signal, and to calculate the correlation value corresponding to each amount of phases (1010), While choosing a maximum correlation value among the correlation values corresponding to each amount of phases the phase revolution known discrimination signal corresponding to each amount of phases -- with a selection means (1020) to choose the response phase revolution known discrimination signal corresponding to a maximum correlation value inside While making small the component except the phase revolution known discrimination signal corresponding to each amount of phases among addition signals, it is characterized by having an updating means (1034) to update antenna weight so that it may leave a response phase revolution known discrimination signal at least among addition signals.
[0039] Thus, an updating means updates the antenna weight which makes small the component except the phase revolution known discrimination signal corresponding to each amount of phases among addition signals. Therefore, the component except the phase revolution known discrimination signal corresponding to each amount of phases can be made small among addition signals. For this reason, control of the phase revolution known discrimination signal corresponding to each amount of phases can be prevented, and since a signal component with the need for oppression can originally be oppressed when control of the phase revolution known discrimination signal corresponding to each amount of phases is unnecessary, the Nur point can be formed in an effective target.
[0040] Furthermore, an updating means updates antenna weight so that it may leave the response phase revolution known discrimination signal corresponding to a maximum correlation value at least among addition signals. Therefore, it can leave the response phase revolution known discrimination signal corresponding to a maximum correlation value at least among addition signals.
[0041] Here, since a response phase revolution known discrimination signal is equivalent to the phase revolution known discrimination signal of a maximum-electric-power value among the phase revolution known discrimination signals corresponding to each amount of phases, it can acquire the big revolution known discrimination signal of a received-power value by leaving a response phase revolution known discrimination signal.
[0042] Two or more antenna elements [invention / according to claim 17] (11 12), A received frequency discrimination means to carry out frequency discrimination of the receiving OFDM signal received by two or more antenna elements, respectively, and to search for a discrimination signal (801 802), The antenna multiplication means which carries out the multiplication of the antenna weight to each discrimination signal by which frequency discrimination was carried out (201 202), An addition means by which antenna weight adds each discrimination signal by which multiplication was carried out, and outputs an addition signal (300), A narrow-band output means to output the narrow-band discrimination signal of a narrow frequency band among each discrimination signal compared with a discrimination signal, respectively (1040), A request frequency judgment means to carry out frequency discrimination of the known OFDM signal, and

to search for a known discrimination signal (83), A known narrow-band output means to output the narrow-band known discrimination signal of a narrow frequency band among known discrimination signals compared with a known discrimination signal (1041), Only the amount of phases which is different to a narrow-band known discrimination signal, respectively carries out a phase revolution. A phase revolution means to search for the signal according to phase rotary valve of the narrow-band corresponding to each amount of phases (1000), A correlation means to take correlation with the signal according to phase rotary valve of the narrow-band corresponding to each amount of phases, and each discrimination signal, and to calculate the correlation value corresponding to each amount of phases (1010), While choosing a maximum correlation value among the correlation values corresponding to each amount of phases A selection means to choose the signal according to phase rotary valve of the narrow-band corresponding to a maximum correlation value among the signals according to phase rotary valve of each narrow-band (1020), While making small the component except the phase revolution known discrimination signal of the narrow-band corresponding to each amount of phases among addition signals, it is characterized by having an updating means (1033) to update so that it may leave at least the signal according to phase rotary valve of the narrow-band which corresponds among addition signals.

[0043] Thus, since an updating means updates the antenna weight which makes small the component except the phase revolution known discrimination signal of the narrow-band corresponding to each amount of phases among addition signals, it can make small the component except the phase revolution known discrimination signal of the narrow-band corresponding to each amount of phases among addition signals. For this reason, control of the phase revolution known discrimination signal of the narrow-band corresponding to each amount of phases can be prevented, and since a signal component with the need for oppression can originally be oppressed when control of the phase revolution known discrimination signal of the narrow-band corresponding to each amount of phases is unnecessary, the Nur point can be formed in an effective target.

[0044] Furthermore, an updating means updates antenna weight so that it may leave the phase revolution known discrimination signal of the narrow-band corresponding to a maximum correlation value at least among addition signals. Therefore, it can leave the phase revolution known discrimination signal of the narrow-band corresponding to a maximum correlation value at least among addition signals.

[0045] Here, since said corresponding phase revolution known discrimination signal of a narrow-band is equivalent to the phase revolution known discrimination signal of a maximum-electric-power value among the phase revolution known discrimination signals corresponding to each amount of phases, it can acquire the big revolution known discrimination signal of a received-power value by leaving said corresponding phase revolution known discrimination signal of a narrow-band.

[0046] Here, since the signal according to phase rotary valve of a narrow-band is used when an updating means updates antenna weight, the amount of operations for updating can be reduced compared with invention according to claim 16.

[0047] Two or more antenna elements [invention / according to claim 18] (11 12), A received frequency discrimination means to carry out frequency discrimination of the receiving OFDM signal received by two or more antenna elements, respectively, and to search for a discrimination signal (801 802), The antenna multiplication means which carries out the multiplication of the antenna weight to each discrimination signal by which frequency discrimination was carried out (201 202), An addition means by which antenna weight adds each discrimination signal by which multiplication was carried out, and outputs an addition signal (300), A narrow-band output means to output the narrow-band discrimination signal of a narrow frequency band among each discrimination signal compared with a discrimination signal, respectively (1040), A request frequency judgment means to carry out frequency discrimination of the known OFDM signal, and to search for a known discrimination signal (83), A known narrow-band output means to output the narrow-band known discrimination signal of a narrow frequency band among known discrimination signals compared with a known discrimination signal (1041), The phase revolution

means (1000) which carries out the phase revolution of the narrow-band known discrimination signal, and the inside of an addition signal, It is characterized by having an updating means (1030A) to update antenna weight so that power of the component except a narrow-band known discrimination signal and said narrow-band known discrimination signal by which the phase revolution was carried out may be made small.
[0048] Thus, since antenna weight is updated so that power of the component except the narrow-band known discrimination signal by which the phase revolution was carried out with the narrow-band known discrimination signal among addition signals may be made small, power of the component except a narrow-band known discrimination signal and said narrow-band known discrimination signal by which the phase revolution was carried out can be made small among addition signals. For this reason, control of a narrow-band known discrimination signal and said narrow-band known discrimination signal by which the phase revolution was carried out can be prevented, and since a signal component with the need for oppression can originally be oppressed when control of a narrow-band known discrimination signal and said narrow-band known discrimination signal by which the phase revolution was carried out is unnecessary, the Nur point can be formed in an effective target.
[0049] Here, since said narrow-band known discrimination signal by which the phase revolution was carried out and signal according to phase rotary valve of a narrow-band are used when an updating means computes antenna weight, the amount of operations for updating can be reduced.
[0050] Incidentally, the sign in the parenthesis of each above-mentioned means is an example which shows response relation with the concrete means of a publication to the operation gestalt mentioned later.
[0051]
[Embodiment of the Invention] (The 1st operation gestalt) The adaptive array antenna of the MMSE method which starts the 1st operation gestalt of this invention at drawing 1 is shown. In a **** 1 operation gestalt, the adaptive array antenna of an MMSE method shows the example which receives an OFDM signal. Drawing 1 is a block diagram about the outline configuration of the adaptive array antenna of an MMSE method. The adaptive array antenna of an MMSE method is an antenna element 11, as shown in drawing 1 . -- They are 1M (M is the natural number) and a multiplier 21. -- It consists of 2M, an adder (sigma) 30, MMSE computing-element 40A, adders 51 and 52, a multiplier 53, and generators 60 and 70. In drawing 1 , the same sign as the sign in drawing 18 shows the same object or a substantial same object.
[0052] A generator 60 generates the preamble signal r0 of an OFDM signal (i) as a request known signal, and this preamble signal r0 (i) is a signal with which two or more pilot symbols (known signal) were arranged on the frequency shaft.
[0053] A generator 70 generates the delay signal of U (U is the natural number) individual to the preamble signal r0 (i) as other known signals, and U delay signals have a different time delay to a preamble signal, respectively. However, each time delay of U delay signals over a preamble signal is short compared with the period TG of the guard interval GI of an OFDM symbol, and is hereafter set to delay signal R (i) which shows U delay signals in a formula 3.
[0054]
[Equation 3]
R -- (-- i --) -- = -- [-- r -- one -- (-- i --) -- -- r -- two -- (-- i --) -- -- rU -- (-- i --) --] -- T -- next -- a multiplier -- 53 -- a formula -- four -- expressing -- a signal -- weight -- AH -- delay -- a signal -- R -- (-- i --) -- multiplication -- carrying out -- a formula -- five -- being shown -- multiplication -- a signal -- {-- AHR -- (-- i --) --} -- outputting .
[0055]
[Equation 4] A= [a1 a2 --aU] T [0056]
[Equation 5] AHR(i) =a1*r1(i)+a2*r2(i) -- aU*rU (i)
Next, an adder 52 adds the preamble signal r0 (i) and the multiplication signal AHR (i), and outputs an addition signal (r0(i)+AHR(i)). Here, an addition signal (r0(i)+AHR(i)) turns into a composite signal (reference sign) of the preamble signal r0 (i) and delay signal R (i). And an adder 51 asks for error [of an addition signal (r0(i)+AHR(i)) and the inner product signal WHX of an

adder 30 (i)] e (i). Here, error e (i) can be expressed to a formula 6.
[0057]
[Equation 6] To e(i) =r0(i)+AHR(i)-WHX, next MMSE computing-element 40A The receiving OFDM signal X (i), delay signal R (i), and error e (i) are inputted. MMSE computing-element 40A for example, SMI (Sample Matrix Inversion) of an MMSE method, while updating the antenna weight W and outputting to a multiplier 21 and 22 --2M so that error e (i) may be made small based on law The signal weight A is updated and it outputs to a multiplier 53 so that error e (i) may be made small based on the SMI method of an MMSE method.
[0058] Thereby, as an inner product signal WHX of an adder 30, the component except preamble signal r0 (i), (request known signal), and delay signal R (i) (other known signals) becomes a repressed signal among the receiving OFDM signals X (i).
[0059] Here, the signal weight A is called for so that MMSE computing-element 40A may show the phase contrast and the amplitude difference of delay signal R (i) and a (the 2nd known signal) on the basis of the preamble signal r0 (i) and (the 1st known signal).
[0060] Hereafter, the description of a **** 1 operation gestalt is described. First, the time delay of delay signal R (i) to the preamble signal r0 can restore data (for example, QPSK data symbol) for the inner product signal WHX of an adder 30 by FFT processing (frequency discrimination), without oppressing delay signal R (i) among the receiving OFDM signals X (i) like ****, since it is short compared with the period TG of the guard interval GI.
[0061] That is, oppression of delay signal R (i) is unnecessary among the receiving OFDM signals X (i). So, with a **** 1 operation gestalt, a repressed signal is acquired for the component except the preamble signal r0 (i) and the delay signal AHR (i) among the receiving OFDM signals X (i) as an inner product signal WHX of an adder 30 like ****.
[0062] For this reason, since oppression of delay signal R (i) is prevented and a signal component with the need for oppression can originally be oppressed, the Nur point can be formed in an effective target. Therefore, useless consumption of the degree of freedom of the adaptive array antenna of an MMSE method can be held down.
[0063] Moreover, since the addition signal (r0(i)+AHR(i)) of the preamble signal r0 (i) and delay signal R (i) is acquired, if it restores to this addition signal as an inner product signal WHX of an adder 30, a good recovery signal will be acquired compared with the case where it restores to the preamble signal r0 (i).
[0064] Here, the result of a simulation is shown in drawing 2 . An axis of abscissa is the receiving include angle [deg] of the received electric wave on the basis of the adaptive array antenna of an MMSE method among drawing 2 , and an axis of ordinate is an oppression ratio (dB). The chain line shows the result of the simulation which used the adaptive array antenna of the conventional MMSE method. A continuous line shows the result of the simulation which used the adaptive array antenna of the MMSE method of a **** 1 operation gestalt.
[0065] Although the delay signal in GI is oppressed in the adaptive array antenna of the conventional MMSE method so that drawing 2 may show, oppression of the delay signal in GI is prevented in the adaptive array antenna of the MMSE method of a **** 1 operation gestalt. However, the delay signal in GI is a delay signal which has a short time delay compared with Period (guard interval GI) TG to a request signal (preamble signal r0).
[0066] Below, the SMI algorithm of the MMSE method of MMSE computing-element 40A in a **** 1 operation gestalt is described. First, error e (i) shown in a formula 6 can be transformed, and error e (i) can be expressed like a formula 7.
[0067]
[Equation 7]

$$\begin{aligned} e(i) &= r_0(i) + R(i)A^H - W^H X \\ &= r_0(i) - \{W^H X - R(i)A^H\} \\ &= r_0(i) - Y^H Z(i) \end{aligned}$$

Y is the antenna weight W and weight including the both sides of the signal weight A here, as shown in a formula 8, and Z (i) is a signal including the both sides of the receiving OFDM signal X

(i) and delay signal R (i), as expressed to a formula 9.
[0068]
[Equation 8] Y= [w1 w2 w3 -- wM-a1-a2-a3 ---aU] T [0069]
[Equation 9] Z -- = -- [-- x -- one -- (-- i --) -- -- x2 -- (-- i --) -- -- x -- three -- (-- i --) .... xM -- (-- i --) -- -- r -- one -- (-- i --) -- -- r -- two -- (-- i --) -- -- r -- three -- (-- i --) -- rU -- (-- i --) --] -- TSMI -- an algorithm -- an odor -- a formula -- ten -- being shown -- a performance index -- Q -- direct -- minimizing . However, alpha is the weighting constant of 0< alpha<=1.
[0070]
[Equation 10]

$$Q(i)=\sum_{i=1}^{G}\alpha^{G-i}|e(i)|^2$$

[0071] Furthermore, the gradient vector about the weight Y of a formula 7 is set with zero, and the least square of a performance index Q is obtained like a formula 11. This formula 11 shows the formula for updating weight Y (G). However, G is time amount (thump rig time amount), and G shows the count of updating of Weight Y (number of steps).
[0072]
[Equation 11]

$$Y(G)=B^{-1}(G)\,b(G)$$

[0073] Here, a formula 12 and a formula 13 are shown for B in a formula 11, and b.
[0074]
[Equation 12]

$$B=\sum_{i=1}^{G}\alpha^{G-i}Z(i)Z^{H}(i)$$

[0075]
[Equation 13]

$$b(G)=\sum_{i=1}^{G}\alpha^{G-i}Z(i)r_0^{*}(i)$$

[0076] (The 2nd operation gestalt) Although the example which adopted the generator 70 was explained with the above-mentioned 1st operation gestalt in order to generate delay signal R (i) and (U delay signals), you may make it generate delay signal R (i) using the preamble signal outputted not only from this but from the generator 60. The configuration in this case is shown in drawing 3 and drawing 4 .
[0077] Drawing 3 is the block diagram showing the configuration of the adaptive array antenna of the MMSE method of a **** 2 operation gestalt, and drawing 4 is drawing showing the detail of the delay circuit in drawing 3 (henceforth a delay circuit 80). With the **** 2 operation gestalt, as shown in drawing 3 , while the generator 60 shown in drawing 1 is deleted, the delay circuit 80 is adopted. In drawing 3 , the same sign as the sign in drawing 1 shows the same object or a substantial same object.
[0078] A delay circuit 80 is arranged between a generator 60 and a multiplier 53, and outputs delay signal R (i) stated with the above-mentioned 1st operation gestalt in response to the preamble signal outputted from the generator 60.
[0079] Specifically, a delay circuit 80 is the delay signal r1 (i) with which the series connection of the delay machines (Z-1) 801, 802, and 803 and the --80U is carried out, it is constituted, and the delay machines 801, 802, and 803 and --80U correspond, respectively as shown in drawing 4 , and r2 (i). -- rU (i) is outputted to MMSE computing-element 40A and a multiplier 53. Other actuation and effectiveness are the same as the above-mentioned 1st operation gestalt.
[0080] (The 3rd operation gestalt) Although the adaptive array antenna of an MMSE method explained the example which adopted the pudding AMBURU signal of an OFDM signal as a signal on a time-axis with the above-mentioned 1st and 2nd operation gestalt, you may make it adopt

each discrimination signal which carried out FFT processing (frequency judgment) of the pudding bull signal of not only this but an OFDM signal. The configuration in this case is shown in drawing 5 – drawing 8 . It is ****** with which drawing 5 is drawing showing the configuration of the adaptive array antenna of a **** 3 operation gestalt, and drawing 6 indicates the detail configuration of the FFT circuit 83 in drawing 5 to be. Drawing 7 is drawing showing actuation of the delay circuit 90 of drawing 5 , and drawing 8 is drawing showing actuation of the FFT circuit in drawing 6 .
[0081] With the **** 3 operation gestalt, as shown in drawing 5 , MMSE arithmetic circuit 40B is replaced with and adopted as MMSE arithmetic circuit 40A in drawing 1 , and Multipliers 201–20M are replaced with and adopted as the multipliers 21–2M in drawing 1 . Multipliers 510–530 are replaced with and adopted as the multipliers 51–53 in drawing 1 . Furthermore, the FFT circuits 801–80M, and 83 and 84 are added. The FFT circuit 801 carries out FFT processing of the pudding AMBURU signal of the receiving OFDM signal x1 of an antenna element 11 (i). The FFT circuit 801 samples only N (N is the natural number) time as every [of the above-mentioned pudding AMBURU signal] effective symbol (refer to drawing 17) (analog to digital conversion), carries out FFT processing based on each sampling signal, and, specifically, is the discrimination signal ft1 for every frequency (1), and ft1 (2). -- ft1 (N) may be outputted. Here, they are the discrimination signal ft1 (1) and ft1 (2). -- ft1 (N) can be summarized and can be expressed with a formula 14. Moreover, N is the count of a sampling of the above-mentioned effective symbol, and is the point size of FFT of the above-mentioned effective symbol.
[0082]
[Equation 14] As substantially as the FFT circuit 801, similarly, the FT1(i) =[ft1(1) ft1(2) ft1(3) -- ft1 (N)] TFFT circuit 802 carries out FFT processing of the pudding AMBURU signal of the receiving OFDM signal x1 of an antenna element 11 (i), and is the discrimination signal ft2 for every frequency (1), and ft2 (2). -- ft2 (N) is outputted. Furthermore, the discrimination signal ft2 (1), ft2 (2) -- ft2 (N) is summarized and can be expressed with a formula 15.
[0083]
[Equation 15] FT2(i) =[ft2(1) ft2(2) ft2(3) --ft2 (N)] TFFT circuit 80M carry out FFT processing of the pudding AMBURU signal of the receiving OFDM signal xM of antenna element 1M (i) similarly substantially with the FFT circuit 801, and are the discrimination signal ftM for every frequency (1), and ftM (2). -- ftM (N) is outputted. Furthermore, the discrimination signal ftM (1), ftM (2) -- ftM (N) is summarized and can be expressed with a formula 16.
[0084]
[Equation 16] FTM(i) =[-- ftM(1) ftM(2) ftM(3) -- ftM (N) --] -- T -- here -- a **** 3 operation gestalt -- FT1 (i), FT2 (i), and -- [0085] made into discrimination signal X (i)' as FTM (i) is summarized and it is shown in a formula 17
[Equation 17] X -- (-- i --) -- ' -- = -- [-- FT -- one -- (-- i --) -- -- FT -- two -- (-- i --) -- FTM -- (-- i --) --] -- T -- next -- a multiplier -- 201 - 20 -- M -- the antenna weight WH -- discrimination signal X (i)' -- multiplication -- carrying out . That is, a multiplier 201 obtains a result (w1*FT1 (i)) in quest of the product of antenna weight w1* and FT1 (i). A multiplier 202 obtains a result (w2*FT2 (i)) in quest of the product of antenna weight w2* and FT2 (i). Furthermore, multiplier 20M obtain a result (wM*FTM (i)) in quest of the product of antenna weight wM* and FTM (i).
[0086] next -- an adder (sigma) -- 300 -- a multiplier -- 201 - 20 -- M -- depending -- a result (w1*FT1 (i)) -- (-- w -- two -- * -- FT -- two -- (-- i --) --) -- (wM*FTM (i)) -- a frequency -- every -- adding -- things -- an antenna -- weight -- W -- discrimination -- a signal -- X -- (-- i --) -- ' -- an inner product -- being shown -- an inner product -- a signal -- WHX -- (-- i --) -- ' -- asking .
[0087] Incidentally, as inner product signal WHX (i)', as shown in a formula 18, the inner product signal of the N individual fx1(1) fx2(2) --fxM(N) is packed. Furthermore, for example, fx1 (1) can express an inner product signal with a formula 19, and the inner product signal fx2 (2) can be expressed with a formula 20. Furthermore, the inner product signal fxM (N) can be expressed with a formula 21.
[0088]

[Equation 18] WHX(i)'= [fx1(1) fx2(2) --fxM(N)] T [0089]
[Equation 19] fx1(1) =w1* and ft1 (1) +w2*, ft2 (1) -- wM*, ftM (1)
[0090]
[Equation 20] fx2(2) =w1* and ft1 (2) +w2*, ft2 (2) -- wM*, ftM (2)
[0091]
[Equation 21] fxM(N) =w1* and ft1 (N) +w2*, ft2 (N) -- wM*, ftM (N)
Next, delay circuits 90 are the delay preamble signals OF (t+tS), OF (t+2, tS), and OF (t+3, tS) over this preamble signal r0 (i), in response to the fact that the preamble signal r0 of an OFDM signal (i) and the (request known signal) from a generator 60, as shown in drawing 6 . -- OF (t+p-tS) is generated.
[0092] However, tS is the time amount which shows the sampling period of the FFT circuits 801-80M, and (p+1) is the count of the sampling at the time of sampling the guard interval GI of an OFDM symbol by time amount tS.
[0093] Thereby, they are the delay preamble signals OF (t+tS) and OF (t+2, tS). -- OF (t+p-tS) has a time delay shorter than the guard interval period TG to the preamble signal r0 (i), respectively. Furthermore, as the number of a delay preamble signal, it is the maximum number defined with the guard interval period TG and a sampling period tS {p=(TG/tS)-1}.
[0094] Here the delay preamble signal OF (t+tS) As shown in drawing 7 , by the signal which delayed only time amount tS to the preamble signal r0 (i) the delay preamble signal OF (t+2, tS) It is the signal which delayed only time amount 2 tS to the preamble signal r0 (i), and the delay preamble signal OF (t+3, tS) is a signal which delayed only time amount 3 and tS to the preamble signal r0 (i). The delay preamble signal OF (t+p-tS) is a signal which delayed only time amount p-tS to the preamble signal r0 (i).
[0095] Next, the FFT circuits 83 are the delay preamble signals OF (t+tS), OF (t+2, tS), and OF (t+3, tS) from a delay circuit 90, as shown in drawing 6 . -- Each effective symbol of OF (t+p-tS) is sampled with a sampling period tS in juxtaposition, and FFT processing is carried out by the sampling signal. Specifically, the FFT circuits 83 are the FFT processing sections 831, 832, and 833. -- It has 83p, and as shown in drawing 8 , the FFT processing section 831 carries out FFT processing of the effective symbol of the delay preamble signal OF (t+tS) with a sampling period tS, and outputs delayed discrimination signal R (1). However, delayed discrimination signal R (1) can be expressed with a formula 22. This delayed discrimination signal R (1) has a signal component for every frequency.
[0096]
[Equation 22] R(1) = -- "-- f1(1) f1(2) f1 (3) -- f1 (N) -- " -- T -- the FFT processing section 832 outputs delayed discrimination signal R (2) shown in a formula 23 again by carrying out FFT processing of the effective symbol of the delay preamble signal OF (t+2, tS) with a sampling period tS, as shown in drawing 8 . This delayed discrimination signal R (2) has a signal component for every frequency. Furthermore, FFT processing section 83p outputs delayed discrimination signal R (p) shown in a formula 24 by carrying out FFT processing of the effective symbol of the delay preamble signal OF (t+p-tS) with a sampling period tS, as shown in drawing 8 . Delayed discrimination signal R (p) has a signal component for every frequency.
[0097]
[Equation 23] R -- (-- two --) -- = -- "-- f -- two -- (-- one --) -- -- f -- two -- (-- two --) -- -- f -- two -- (-- three --) -- f -- two -- (-- N --) -- " -- T -- [-- 0098 --]
[Equation 24] R -- (-- p --) -- = -- "-- fp -- (-- one --) -- -- fp -- (-- two --) -- -- fp -- (-- three --) -- fp -- (-- N --) -- " -- T -- next -- drawing 5 -- being shown -- FFT -- a circuit -- 84 -- drawing 8 -- being shown -- as -- the preamble signal r0 of the OFDM signal from a generator 60 (i) -- (-- = -- the effective symbol of OF (t)) is sampled with a sampling period tS, and FFT processing is carried out by these sampling signal. Thereby, the FFT circuit 84 outputs request discrimination signal r0 (i)', as shown in a formula 25. Request discrimination signal r0 (i)' has a signal component for every frequency.
[0099]
[Equation 25] r -- zero -- (-- i --) -- ' -- = -- "-- f -- zero -- (-- one --) -- -- f -- zero -- (-- two --) -- -- f -- zero -- (-- three --) -- f -- zero -- (-- N --) -- " -- T -- next -- a

multiplier -- 530 -- the product of the signal weight AH and delayed discrimination signal R (i) -- taking -- an output signal {AHR (i)} -- outputting . However, the signal weight A in a **** 3 operation gestalt is shown in a formula 26. In addition, an output signal {AHR (i)} packs the output signal of N individual, and is written.

[0100]

[Equation 26] An adder 520 adds the output signal {AHR (i)} of a multiplier 530, and request discrimination signal r0 (i)' to an A=[a1 a2 --aP] T pan, and outputs an addition signal (r0(i)'+AHR (i)) to it. An adder 510 asks for error [with addition signal (r0(i)'+AHR(i)) and inner product signal / of an adder 30 / WHX (i)'] e (i).

[0101] Here, to MMSE computing-element 40B, discrimination signal X (i)', and delayed discrimination signal R (i) and error e (i) are inputted, and MMSE computing-element 40B updates the signal weight A while updating the antenna weight W like the above-mentioned 1st and 2nd operation gestalt so that error e (i) may be made small based on the SMI method of an MMSE method. Thereby, as inner product signal [of an adder 300] WHX (i)', the component except request discrimination signal r0 (i)' (request known signal) and delayed discrimination signal R (i) (other known signals) becomes a repressed signal among discrimination signal X (i)'. Thereby, the same effectiveness is substantially acquired with the above-mentioned 1st and 2nd operation gestalt.

[0102] In addition, at the above-mentioned 3rd operation gestalt, they are the delay preamble signals OF (t+tS), OF (t+2, tS), and OF (t+3, tS). -- Although the example which obtained delayed discrimination signal R (i) based on OF (t+p-tS) was explained, delayed discrimination signal R (i) may be obtained not only based on this but based on request discrimination signal r0 (i)'.

[0103] (The 4th operation gestalt) Although the adaptive array antenna of an MMSE method explained the example which receives an OFDM signal with the above-mentioned 1-3rd operation gestalt, the adaptive array antenna of not only this but an MMSE method may be applied to a CDMA communication link. The configuration in this case is shown in drawing 9 .

[0104] The matched filter 100 and the RAKE composition machine 110 are added and constituted from drawing 9 by the circuit shown in drawing 3 . Furthermore, it replaces with the delay circuit 80 shown in drawing 3 , and delay circuit 80A is adopted. In drawing 9 , the same sign as the sign in drawing 1 shows the same object or a substantial same object. however -- each -- ANTENANA component 11 --1M -- an OFDM signal -- replacing with -- a CDMA signal -- receiving -- the receiving CDMA signal x1 (i), x2 (i), and -- xM (i) is outputted.

[0105] Next, actuation of a **** 4 operation gestalt is explained with reference to drawing 10 . Hereafter, four antenna elements 11-14 are adopted, and the example to which antenna elements 11-14 output each is explained. A matched filter 100 performs correlation detection with the pilot signal (known signal) (i) r0 from each and a generator 60 for the receiving CDMA signal x1 (i), x2 (i), x3 (i), and x4 (i) in juxtaposition.

[0106] concrete -- a matched filter 100 -- the 1- it has the 4th matched filter section (not shown). The 1st matched filter section carries out correlation detection of the receiving CDMA signal x1 (i) and a pilot signal r0 (i), and outputs a correlation signal (refer to drawing 10 (a)), and the 2nd matched filter section considers correlation detection with a pilot signal r0 (i) as receiving CDMA signal x2 (i), and outputs a correlation signal (refer to drawing 10 (b)).

[0107] The 3rd matched filter section carries out correlation detection of the receiving CDMA signal x3 (i) and a pilot signal r0 (i), and outputs a correlation signal (refer to drawing 10 (c)), and the 4th matched filter section carries out correlation detection of the receiving CDMA signal x4 (i) and a pilot signal r0 (i), and outputs a correlation signal (refer to drawing 10 (d)). However, by drawing 10 (a) - (d), an axis of ordinate shows a correlation value, and an axis of abscissa shows time amount by it.

[0108] here -- a matched filter 100 -- the 1- the correlation signal from the 4th matched filter section is added, and the delay information on the basis of the time of the input of a pilot signal r0 (i) and a (request signal) is acquired based on the addition result. This delay information shows the delay signal of a time delay shorter than desired time amount among receiving CDMA signal x1(i) -x4(i). The example shown in drawing 10 (e) shows the example of ** from which td1, td2,

td3-td6 are obtained as delay information. Then, using the delay information td1-td6, delay circuit 80A outputs delay signal R (i) and (other known signals), as shown in drawing 10 (f).
[0109] That is, delay circuit 80A is r0 (t+td1), r0 (t+td2), and r0 (t+td2). -- r0 (t+td6) is outputted. For example, to a pilot signal r0 (i), only the time delay td1 is delayed and, as for r0 (t+td2), only the time delay td2 is delayed by r0 (t+td1) to a pilot signal r0 (i). As for r0 (t+td6), only the time delay td6 is delayed to a pilot signal r0 (i). Other actuation is substantially [as the circuit shown in drawing 3] the same.
[0110] By the above, it is the receiving CDMA signal x1 (i) as an inner product signal WHX from an adder (sigma). -- A repressed signal is acquired for the component except a pilot signal r0 (i) (request signal) and its delay signals r0 (t+td1)-r0 (t+td6) (other known signals) among xM(s) (i). And the RAKE composition machine 110 will perform a RAKE composition recovery using the inner product signal WHX concerned. if a signal required for a RAKE composition recovery is prepared here as delay signals r0 (t+td1)-r0 (t+td6) -- an oppression of a signal unnecessary for a RAKE composition recovery sake -- null -- a point can be formed. Therefore, useless consumption of the degree of freedom of the adaptive array antenna of an MMSE method can be held down like the above-mentioned 1st operation gestalt.
[0111] In addition, the adaptive array antenna of an MMSE method is applied to the communication link of a CDMA method, and although the example which acquires the delay information on the CDMA input signal X (i) with a matched filter 100 was shown, you may make it acquire the delay information on the receiving OFDM signal of not only this but the above-mentioned 1st and 2nd operation gestalt with a matched filter 100 in the above-mentioned 4th operation gestalt.
[0112] (The 5th operation gestalt) Although the 2 above-mentioned operation gestalten explained the example which set up beforehand a request known signal and other known signal ****, you may make it choose a request known signal and other known signals among delay signal R (i) not only according to this but according to the receiving OFDM signal X (i).
[0113] The configuration in this case is shown in drawing 11 and drawing 12 . Drawing 11 shows the configuration of the adaptive array antenna of the MMSE method in a **** 5 operation gestalt. Drawing 12 shows the detail configuration of the request signal selection circuitry in drawing 11 (following and request signal selection circuitry 130).
[0114] As the adaptive array antenna of the MMSE method of a **** 5 operation gestalt is shown in drawing 11 , the request signal selection circuitry 130 is added to the circuit shown in drawing 3 . In drawing 11 , the same sign which drawing 3 shows shows the same object or a real target the same object.
[0115] A delay circuit 90 receives the preamble signal r0 from a generator 60 (i), and is the delay preamble signals OF (t+tS) and OF (t+2, tS). -- OF (t+U-tS) is generated. However, U is the delay preamble signal [as opposed to / are the natural number and / the preamble signal r0 (i)] OF (t+tS). -- Each time delay of OF (t+U-tS) is short compared with the guard interval period TG of an OFDM signal.
[0116] the receiving OFDM signal X (i) and delay preamble signal OF(t+tS) --OF (t+U-tS) input into the request signal selection circuitry 130 -- having -- the request signal selection circuitry 130 -- the receiving OFDM signal X (i) -- responding -- delay preamble signal OF(t+tS) -- request known signal r0 (i)' and delay signal R (i) are chosen among OF(s) (t+U-tS).
[0117] Specifically, the request signal selection circuitry 130 consists of Correlators 131a-131c, 132a-132c, 133a-133c, 134a-134c, adders (sigma) 135a-135c, a maximum judging machine 136, and a selection circuitry 137, as shown in drawing 12 .
[0118] Next, actuation of a **** 5 operation gestalt is explained with reference to drawing 12 . The example which adopted only four antenna elements called antenna elements 11-14, and adopted three delay preamble signals of the delay preamble signals OF (t+tS), OF (t+2, tS), and OF (t+3, tS) hereafter is explained. First, antenna elements 11-14 output the receiving OFDM signal x1 (i), x2 (i), x3 (i), and x4 (i), respectively.
[0119] Next, correlator 131a performs correlation detection of the delay preamble signal OF (t+tS) and the receiving OFDM signal x1 (i), and correlator 132a performs correlation detection of the delay preamble signal OF (t+tS) and receiving OFDM signal x2 (i). Correlator 133a

performs correlation detection of the delay preamble signal OF (t+tS) and the receiving OFDM signal x3 (i), and correlator 134a performs correlation detection of the delay preamble signal OF (t+tS) and the receiving OFDM signal x4 (i).
[0120] Adder 135a adds the correlation detecting signal from each of Correlators 131a, 132a, 133a, and 134a, and outputs an addition signal. Here, the addition signal of adder 135a shows correlation with the delay preamble signal OF (t+tS), the receiving OFDM signal x1 (i), x2 (i), x3 (i), and x4 (i).
[0121] Next, correlator 131b performs correlation detection of the delay preamble signal OF (t+2, tS) and the receiving OFDM signal x1 (i), and correlator 132b performs correlation detection of the delay preamble signal OF (t+2, tS) and receiving OFDM signal x2 (i). Correlator 133b performs correlation detection of the delay preamble signal OF (t+2, tS) and the receiving OFDM signal x3 (i), and correlator 134b performs correlation detection of the delay preamble signal OF (t+2, tS) and the receiving OFDM signal x4 (i).
[0122] Adder 135b adds the correlation detecting signal from each of Correlators 131b, 132b, 133b, and 134b, and outputs an addition signal. The addition signal of adder 135b shows correlation with the delay preamble signal OF (t+2, tS), the receiving OFDM signal x1 (i), x2 (i), x3 (i), and x4 (i).
[0123] Next, correlator 131c performs correlation detection of the delay preamble signal OF (t+3, tS) and the receiving OFDM signal x1 (i), and correlator 132c performs correlation detection of the delay preamble signal OF (t+3, tS) and receiving OFDM signal x2 (i). Correlator 133c performs correlation detection of the delay preamble signal OF (t+3, tS) and the receiving OFDM signal x3 (i), and correlator 134c performs correlation detection of the delay preamble signal OF (t+3, tS) and the receiving OFDM signal x4 (i).
[0124] Adder 135c adds the correlation detecting signal from each of Correlators 131c, 132c, 133c, and 134c, and outputs an addition signal. The addition signal of adder 135c shows correlation with the delay preamble signal OF (t+3, tS), the receiving OFDM signal x1 (i), x2 (i), x3 (i), and x4 (i).
[0125] Next, the maximum judging machine 136 judges the addition signal (henceforth a maximum addition signal) which serves as maximum among each addition signal from Adders 135a-135c, and outputs the maximum recognition signal which shows this maximum addition signal to a selection circuitry 137. Among the delay preamble signals OF (t+tS), OF (t+2, tS), and OF (t+3, tS), a selection circuitry 137 chooses the delay preamble signal corresponding to a maximum recognition signal as request known signal r(i)', and outputs it. Furthermore, a selection circuitry 137 outputs two delay preamble signals except the delay preamble signal corresponding to a maximum recognition signal as other known signals R (i) among the delay preamble signals OF (t+tS), OF (t+2, tS), and OF (t+3, tS). Other actuation is substantially [as the above-mentioned 2nd operation gestalt] the same.
[0126] In addition, in the above-mentioned 5th operation gestalt, although the example which adopted four antenna elements 11-14 was explained, if the number of not only this but an antenna element is two or more pieces, it is good without limit. Furthermore, although the above-mentioned 5th operation gestalt explained per [which adopted three delay preamble signals OF (t+tS), OF (t+2, tS), and OF (t+3, tS)] example, any number of numbers of not only this but a delay preamble signal are good.
[0127] In addition, as correlator shown in a **** 5 operation gestalt, various correlators, such as slide correlator and a matched filter, may be applied in operation of this invention.
[0128] (The 6th operation gestalt) With a **** 6 operation gestalt, the circuit where the equalizing circuit (henceforth an equalizing circuit 120) was added is adopted as the circuit of the above-mentioned 2nd operation gestalt, by the equalizing circuit 120, others and a known signal are oppressed among the inner product signals WHX of an adder 30 (i), and the repressed signal is outputted as an output signal. The configuration in this case is shown in drawing 13 and drawing 14 .
[0129] Drawing 13 is drawing showing the configuration of the adaptive array antenna of the MMSE method of a **** 6 operation gestalt. Drawing 14 shows the detail configuration of the equalizing circuit 120 in drawing 13 . In drawing 13 , the same sign in drawing 3 shows the same

object or a real target the same object.
[0130] With the **** 6 operation gestalt, the adaptive array antenna of an MMSE method is applied to the QPSK communication mode instead of an OFDM communication mode. For this reason, antenna elements 11-1M receive a QPSK signal (pilot signal).
[0131] Therefore, antenna elements 11-1M are replaced with the receiving OFDM signal X (i), and output the receiving QPSK signal X (i), respectively. Moreover, the generating circuit 60 outputs the pilot signal r0 of a QPSK signal (i) as a request known signal, and a delay circuit 90 outputs delay pilot signal R (i) for which only the request period was delayed to the pilot signal r0 of a QPSK signal (i) as other known signals. MMSE computing-element 40A updates the antenna weight WH and the signal weight AH similarly substantially with the above-mentioned 2nd operation gestalt. Moreover, the component excluding [an adder (sigma) 30] the both sides of a request pilot signal (request known signal) and its delay pilot signal (other known signals) among the receiving QPSK signals X (i) outputs a repressed signal as an inner product signal WHX. Moreover, the equalizing circuit 120 consists of delay machines (Z-1) 121-124, multipliers 125-128, and adders 129 and 130, as shown in drawing 14 . Next, actuation of the equalizing circuit 120 of a **** 6 operation gestalt is explained with reference to drawing 14 and drawing 15 .
[0132] Hereafter, as shown in drawing 15 (a), the example as which total with request pilot signal QP1 and the delay pilot signals QP2-QP5 was adopted is explained as an inner product signal WHX of an adder (sigma) 30.
[0133] Since four delay pilot signals of the delay pilot signals QP2-QP5 are adopted here, the signal weight (henceforth signal weight A (G)) of MMSE computing-element 40A in a **** 6 operation gestalt can be expressed with a formula 27. G is sampling timing (updating timing) (G=t1, t2, t3 --). Moreover, drawing 15 (b) shows the output of the delay machines 121-124 in timing t1-t5.
[0134]
[Equation 27] A(G) = -- ″-- a1 [ ] (G) -- a2 [ ] (G) -- a3 (G) -- a4 (G) --] -- T -- the QPSK symbol ZA shown in drawing 15 (a) is first inputted into the delay machine 121 through an adder 130 to timing t1. That is, an equalizing circuit 120 can output the QPSK symbol ZA to timing t1.
[0135] Next, to timing t2, as shown in drawing 15 (b), the delay machine 121 outputs the QPSK symbol ZA to the delay machine 122 while outputting the QPSK symbol ZA to a multiplier 127. Then, a multiplier 128 carries out the multiplication of signal weight a1(t2) * to the QPSK symbol ZA, and outputs a multiplication signal (a1(t2) *ZA) to an adder 129.
[0136] Here, as the above-mentioned 1st operation gestalt described, signal weight a1(t2) * (signal weight AH) is called for so that MMSE computing-element 40A may show the phase contrast and the amplitude difference of the QPSK symbol ZA1 {delay signal R (i)} on the basis of the QPSK symbol ZA {the preamble signal r0 (i)}. For this reason, a multiplication signal (a1(t2) *ZA) becomes equal to the QPSK symbol ZA1 (ZA1=a1(t2) *ZA).
[0137] Thereby, a multiplier 128 can output the multiplication signal ZA1 to an adder 130 through an adder 129. Moreover, the QPSK symbols ZB and ZA1 are inputted into an adder 130 as an inner product signal WHX of an adder (sigma) 30. An adder 130 outputs a differential signal (= ZB) to the delay machine 121 in quest of the difference of the QPSK symbols ZB and ZA1 and the multiplication signal ZA1. That is, an equalizing circuit 120 can output the QPSK symbol ZB to timing t2.
[0138] Next, to timing t3, the delay machine 122 outputs the QPSK symbol ZA to the delay machine 123 while outputting the QPSK symbol ZA to a multiplier 127, as shown in drawing 15 (b). Then, a multiplier 127 carries out the multiplication of signal weight a2(t3) * to the QPSK symbol ZA, and outputs a multiplication signal (a2(t3) *ZA) to an adder 129.
[0139] Here, as the above-mentioned 1st operation gestalt described, signal weight a2(t3) *ZA (signal weight AH) is calculated so that MMSE computing-element 40A may show the phase contrast and the amplitude difference of the QPSK symbol ZA2 {delay signal R (i)} on the basis of the QPSK symbol ZA {the preamble signal r0 (i)}. For this reason, a multiplication signal (a2(t3) *ZA) becomes equal to the QPSK symbol ZA2 (ZA2=a2(t3) *ZA). Therefore, a multiplier 127 outputs the QPSK symbol ZA2 to an adder 129.
[0140] Moreover, the delay machine 121 outputs the QPSK symbol ZB to the delay machine 122

while outputting the QPSK symbol ZB to a multiplier 128, as shown in drawing 15 (b). A multiplier 128 carries out the multiplication of signal weight a1(t3) * to the QPSK symbol ZB, and outputs a multiplication signal (a1(t3) *ZB) to an adder 129.
[0141] Here, as the above-mentioned 1st operation gestalt described, signal weight a1(t3) * (signal weight AH) is called for so that MMSE computing-element 40A may show the phase contrast and the amplitude difference of the QPSK symbol ZB1 {delay signal R (i)} on the basis of the QPSK symbol ZB {the preamble signal r0 (i)}.
[0142] Therefore, a multiplication signal (a1(t3) *ZB) becomes equal to the QPSK symbol ZB1 (ZB1=a1(t3) *ZB). Therefore, a multiplier 127 can output the multiplication signal ZB1 to an adder 129.
[0143] Here, an adder 129 adds the multiplication signal ZB1 of a multiplier 127, and the QPSK symbol ZA2 of an adder 129, and outputs an addition signal (ZB1+ZA2) to an adder 130. The QPSK symbols ZC, ZB1, and ZA2 are inputted into an adder 130 as an inner product signal WHX of an adder (sigma) 30, and an adder 130 asks for the difference of the QPSK symbols ZC, ZB1, and ZA2 and an addition signal (ZB1+ZA2), and outputs a differential signal ZC to the delay machine 121.
[0144] That is, an equalizing circuit 120 can output the QPSK symbol ZC to timing t3. Hereafter, an equalizing circuit 120 operates similarly substantially with above-mentioned actuation, by timing t4, outputs the QPSK symbol ZD and outputs the QPSK symbol ZE to timing t5.
[0145] By the above, an equalizing circuit 120 can output only QPSK symbol ZA-ZD like ****. If it puts in another way, as an inner product signal WHX of an adder (sigma) 30, total with request pilot signal QP1 and the delay pilot signals QP2-QP5 will be inputted into an equalizing circuit 120, it will oppress the delay pilot signals QP2-QP5, and will output only request pilot signal QP1.

[0146] In addition, although the above-mentioned 6th operation gestalt explained the example which applied the adaptive array antenna of an MMSE method to the QPSK communication mode, you may apply not only to this but to an OFDM communication mode.
[0147] Furthermore, it is in charge of operation of this invention, and various communication modes may be adopted in addition to an OFDM communication mode, a CDMA communication mode, the communication mode using a QPSK modulation, etc.
[0148] In addition, although the 1st - the 6th operation gestalt explained the example which adopted the SMI algorithm of an MMSE method with the MMSE computing elements 40A and 40B, other algorithms may be adopted as long as it is an MMSE method.
[0149] When an interference wave comes from the same direction as a request signal in the (7th operation gestalt) and time in the adaptive array antenna of the MMSE method stated with the above-mentioned 1st operation gestalt, there is a problem that the interference wave cannot be oppressed. namely, in the adaptive array antenna of the MMSE method stated with the above-mentioned 1st operation gestalt Although the component except the preamble signal r0 (i) and delay signal R (i) becomes a repressed signal among the receiving OFDM signals X (i), the inner product signal WHX of an adder 30 When a delay-GI outside signal (interference wave) comes from the same direction as the preamble signal r0 (i), the GI delay signal can be controlled.
[0150] It is well-known to oppress without distinguishing the request signal and interference wave which are contained in it in an incoming wave component in the adaptive array antenna of the conventional PI method. Then, in a **** 7 operation gestalt, it explains per [oppresses the interference wave which accomplished paying attention to the adaptive array antenna of the conventional PI method, and prevents oppression of the both sides of a request wave and the delay signal in GI, and comes from the same direction as a request signal and it is made to raise the communication link engine performance] example. The configuration in this case is shown in drawing 16 .
[0151] The adaptive array antenna of PI method is antenna elements 11-14 and a multiplier 21. -- It consists of 2M, an adder (sigma) 30, the PI computing element 41, adder 51A, multiplier 53A, and delay circuit 80A. In drawing 16 , the same sign as the sign in drawing 1 shows the same object or a substantial same object.
[0152] Delay circuit 80A outputs this preamble signal r0 (i) and delay signal R (i) in response to

the preamble signal r0 (i) stated with the above-mentioned 1st operation gestalt. Hereafter, the output signal of delay circuit 80A is called output signal R(i)'.
[0153] However, like ****, the time delay of delay signal R (i) to a preamble signal is short compared with the period TG of the guard interval GI of an OFDM symbol, and sets the number (sample point size) of delay signal R (i) to 16.
[0154] Multiplier 53A carries out the multiplication of the signal weight AH to output signal R(i)', and searches for a multiplication signal {AHR(i)'}. Adder 51A adds a multiplication signal {AHR(i)'} and the inner product signal WHX of an adder 30 (i), and asks for an addition reference sign (WHX(i)+AHR(i)').
[0155] Addition reference-sign (WHX(i)+AHR(i)') and output signal R(i)' and the receiving OFDM signal X (i) are inputted into the PI computing element 41, and the PI computing element 41 updates the antenna weight W and the signal weight A so that power |WHX(i)+AHR(i)'|2 of an addition reference sign may be made into min. At this time, the signal weight A turns into weight which negates output signal R(i)' among the signal components contained in the inner product signal WHX (i), and the antenna weight W turns into weight which makes min power of the interference wave component contained in the receiving OFDM signal X (i).
[0156] If it puts in another way, the PI computing element 41 will update the antenna weight W and the signal weight A so that power of the component except output signal R(i)' may be made into min among the power (WHX(i)+AHR(i)') of an addition reference sign.
[0157] In drawing 17 , the result of a simulation when a request signal and a delay-GI outside signal come from the same is shown. In drawing 17 , when the 1st - the 5th wave come, the directivity after actuation of the adaptive array antenna of the adaptive array antenna of PI method and an MMSE method is shown. The receiving include angle [deg] of the received [a right longitudinal shaft] electric wave on the basis of the adaptive array antenna of an MMSE method and a left-vertical shaft are the receiving include angles [deg] of the received electric wave on the basis of the adaptive array antenna of PI method. An axis of abscissa is an oppression ratio (dB).
[0158] In drawing 17 , since antenna gain differs, it expresses with the adaptive array antenna of an MMSE method, and the adaptive array antenna of PI method that the gain of the direction of delay ****** in GI becomes the same.
[0159] Here, the chain line shows the result of the simulation which used the adaptive array antenna of an MMSE method. A continuous line shows the result of the simulation which used the adaptive array antenna of PI method. Although the delay-GI outside signal of the same direction as a request signal is not oppressed in the adaptive array antenna of an MMSE method so that drawing 17 may show, the delay-GI outside signal of the same direction as a request signal is oppressed in the adaptive array antenna of PI method.
[0160] (The 8th operation gestalt) With the **** 8 operation gestalt, as shown in drawing 18 , low pass filters 420-425 are added to the configuration which the above-mentioned 7th operation gestalt shows. In drawing 18 , low pass filters 420-424 search for the OFDM signal signal of a narrow-band based on the receiving OFDM signal X (i).
[0161] Low pass filters 420-424 output a narrow-band OFDM signal signal by taking out only the component (referring to drawing 19) of the predetermined frequency band among the receiving OFDM signals X (i). That is, the OFDM signal signal of a narrow-band turns into a signal which narrowed the frequency band of the receiving OFDM signal X (i).
[0162] A low pass filter 425 searches for a narrow-band preamble signal based on the preamble signal r0 (i). that is, the low pass filter 425 -- the preamble signal r0 (i) -- a narrow-band preamble signal is outputted by taking out only the component of the predetermined frequency band inside.
[0163] In connection with this, delay circuit 80A searches for the delay signal of U (drawing 19 8) individual which has a different time delay to a narrow-band preamble signal, and outputs the both sides of this delay signal and a narrow-band preamble signal as output signal R(i)'. However, the time delay of the delay signal over a preamble signal is short like **** compared with the period TG of the guard interval GI of an OFDM symbol.
[0164] Here, among output signal R(i)', the number of adoption of a delay signal (sample point)

can be reduced, if it is decided by the frequency band of the receiving OFDM signal X (i) and the frequency band is narrowed.
[0165] then -- **** -- eight -- operation -- a gestalt -- PI -- a computing element -- 41 -- an antenna -- weight -- W -- and -- a signal -- weight -- A -- updating -- hitting -- OFDM -- a signal -- a signal -- replacing with -- a narrow-band -- OFDM -- a signal -- a signal -- adopting -- a preamble -- a signal -- having been based -- an output signal -- R -- (-- i --) -- ' -- replacing with -- a narrow-band -- a preamble -- a signal -- having been based -- an output signal -- R -- (-- i --) -- ' -- adopting . For this reason, not to mention reducing the number of adoption of R (i), it becomes possible about the antenna weight W and the signal weight A to reduce the count of updating, and the computational complexity of renewal of weight can be reduced.
[0166] (The 9th operation gestalt) Although the above-mentioned 3rd operation gestalt explained the adaptive array antenna of the MMSE method which adopted the pudding AMBURU signal of an OFDM signal as a signal on a time-axis, a **** 9 operation gestalt explains per adaptive array antenna of PI method which adopted each discrimination signal which carried out FFT processing (frequency judgment) of the pudding bull signal of not only this but an OFDM signal. The configuration in this case is shown in drawing 20 .
[0167] The adaptive array antenna of PI method consists of antenna elements 11-14, a multiplier 201--204, an adder (sigma) 300, the FFT circuits 801-804, the FFT circuit 834, the PI computing element 42, adder 510A, multiplier 530A, and delay circuit 80A. In drawing 20 , the same sign as the sign in drawing 5 shows the same object.
[0168] As the above-mentioned 8th operation gestalt described, delay circuit 80A combines the preamble signal r0 (i) and delay signal R (i), and outputs them as output signal R(i)'. The FFT circuit 834 samples each effective symbol of the preamble signal r0 (i) and delay signal R (i) with a sampling period tS in juxtaposition, carries out FFT processing by the sampling signal, and outputs the discrimination signal RFT (i).
[0169] Multiplier 530A carries out the multiplication of the signal weight AH to the discrimination signal RFT (i), and searches for a multiplication signal {AHRFT (i)}. Adder 510A adds multiplication signal {AHRFT (i)} and inner product signal [of an adder 300] WHX (i)', and asks for an addition reference sign (WHX(i)'+AHRFT (i)).
[0170] Discrimination signal X (i)', and an addition reference sign (WHX (i) '+AHRFT (i)') and the discrimination signal RFT (i) are inputted into the PI computing element 42, and the PI computing element 42 updates the antenna weight W and the signal weight A so that power |WHX (i)'+AHRFT(i)'|2 of an addition reference sign may be made into min. At this time, the signal weight A turns into weight which negates the discrimination signal RFT (i) among the signal components contained in inner product signal WHX (i)', and the antenna weight W turns into weight which makes min power of the interference wave component contained in discrimination signal X (i)'.
[0171] If it puts in another way, the PI computing element 42 will update the antenna weight W and the signal weight A so that power of the component except the discrimination signal RFT (i) may be made into min among addition reference signs (WHX (i) '+AHRFT (i)').
(The 10th operation gestalt) The adaptive array antenna of the SMI method in a **** 10 operation gestalt consists of antenna elements 11 and 12, a generator 60, the FFT circuits 83, 801, and 802, multipliers 201 and 202, an adder (sigma) 300, the phase revolution machine 1000, correlator 1010, a selection circuitry 1020, and a computing element 1030, as shown in drawing 21 .
[0172] A computing element 1030 has the matrix-of-correlation presumption machine 1031, the inverse-matrix computing element 1032, the correlation vector presumption machine 1033, and the matrix multiplication machine 1034. In addition, in drawing 21 , the same sign in drawing 1 and drawing 2 shows the same object.
[0173] First, FFT processing of the pudding AMBURU signal of the receiving OFDM signal x1 (i) received by the antenna element 11 is carried out in the FFT circuit 801, and the discrimination signal ft1 (1), ft1 (2), ft1 (3), and ft1 (4) are calculated for every frequency. Moreover, FFT processing of the receiving OFDM signal x2 (i) received by the antenna element 12 is carried out

in the FFT circuit 802, and the discrimination signal ft2 (1), ft2 (2), ft2 (3), and ft2 (4) are calculated for every frequency. In addition, the figure 1--4 in the parenthesis of a discrimination signal shows the point size of FFT.
[0174] Here, the vector notation of receiving OFDM signal x1(i) x2(i) discrimination signal ft1(1) -ft1 (3) and the discrimination signal ft2(1) -ft2 (3) is carried out as follows.
[0175]
[Equation 28] X(i) = [x1(i) x2 (i)] T [0176]
[Equation 29] FT1 (i) = [ft1(1) ft1(2) ft1 (3)] T [0177]
[Equation 30] The FT2(i) =[ft2(1) ft2(2) ft2 (3)] T multiplier 201 asks for the matrix product (w1*FT1 (i)) of antenna weight w1* and FT1 (i), and a multiplier 202 asks for the matrix product (w2*FT2 (i)) of antenna weight w2* and FT2 (i).
[0178] Next, an adder (sigma) 300 adds the matrix product (w1*FT1 (i)) by multipliers 201 and 202, and (w2*FT2 (i)) for every frequency. namely, -- a matrix -- a product (w1*FT1 (i)) -- (-- w -- two -- * -- FT -- two -- (-- i --) --) -- an antenna -- weight -- w -- one -- * -- w -- two -- * -- a formula -- 31 -- 32 -- like -- a vector -- a notation -- carrying out -- if -- an adder (sigma) -- 300 -- an antenna -- weight -- W -- discrimination -- a signal -- X -- (-- i --) -- ' -- an inner product -- being shown -- an inner product -- a signal -- WHX -- (-- i --) -- ' -- asking -- having . Moreover, as shown in a formula 33, the vector notation of inner product signal WHX (i)' is carried out.
[0179]
[Equation 31]
X(i)'= [FT1(i) FT2 (i)] T [0180]
[Equation 32] W= [w1 w2] T [0181]
[Equation 33] WHX(i)'= [w1*ft1(1)+w2*ft2(1) w1*ft1(2)+w2*ft2(2) w1*ft1(3)+w2*ft2 (3)] T, next a generator 60 as a request known signal Generating the preamble signal r0 of an OFDM signal (i), this preamble signal r0 (i) is a signal with which two or more pilot symbols (known signal) were arranged on the frequency shaft. Moreover, the FFT circuit 83 carries out FFT processing of the preamble signal r0 of an OFDM signal (i), and calculates the request discrimination signal rf1 (1), rf1 (2), and rf1 (3) for every frequency.
[0182] Next, only four sorts of amounts of phases (0degreetheta**, 2theta** 3theta**) carry out revolution processing of the request discrimination signal rf1 (1), and the phase revolution machine 1000 outputs these request discrimination signals rf1 (1 theta), rf1 (1 2theta), and rf1 (1 3theta) by which revolution processing was carried out, and the request discrimination signal rf1 (1).
[0183] Furthermore, only four sorts of amounts of phases (0 degree, theta**, 2theta**, 3theta**) carry out revolution processing of the request discrimination signal rf1 (2), and the phase revolution machine 1000 outputs these request discrimination signals rf1 (2 theta), rf1 (2 2theta), and rf1 (2 3theta) by which revolution processing was carried out, and the request discrimination signal rf1 (2).
[0184] Moreover, only four sorts of amounts of phases (0degreetheta**, 2theta** 3theta**) carry out revolution processing of the request discrimination signal rf1 (3), and the phase revolution machine 1000 outputs these request discrimination signals rf1 (3 theta), rf1 (3 2theta), and rf1 (3 3theta) by which revolution processing was carried out, and the request discrimination signal rf1 (3).
[0185] Here, request discrimination signal rf1(1) -rf1 (1 3theta), rf1(2) -rf1 (2 3theta), and rf1(3) -rf1 (3 3theta) are calculated as shown in a formula 34.
[0186]
[Equation 34]

$$BS=\begin{bmatrix} C_{11} & C_{12} & C_{13} \\ C_{21} & C_{22} & C_{23} \\ C_{31} & C_{32} & C_{33} \\ C_{41} & C_{42} & C_{43} \end{bmatrix}\begin{bmatrix} rf_1(1) & 0 & 0 \\ 0 & rf_1(2) & 0 \\ 0 & 0 & rf_1(3) \end{bmatrix}$$

[0187] However, the amount of phases which shows Ctf in a formula 35, the number t indicates the amount of phases to be, and f are numbers which show a frequency. Moreover, they are C11=C12=C13, C21=C22=C23, and C31=C32=C33 with a formula 35.
[0188]
[Equation 35] Ctf=exp {-2pij-(j-1) - (t-1)/3}
Here, the output signal of the phase revolution machine 1000 is equivalent to what combined the output signal of the FFT circuit 84 and the output signal of the FFT circuit 83 which are shown in drawing 5 . That is, the FFT circuit 84 generates a time delay shorter than the guard interval period TG to the preamble signal r0 (i) with the phase revolution machine 1000, and plays a role equivalent to carrying out FFT processing of this generated time delay.
[0189] Next, correlator 1010 calculates the correlation value K of the request processing signal BS and discrimination signal X (i)'. In addition, the correlation value K is calculated by the matrix product (BSxX (i) ') of the request processing signal BS and discrimination signal X (i)'.
[0190] Based on the correlation value K, as for a selection circuitry 1020, the request processing signal BSmax with the largest correlation with discrimination signal X (i)' among the request processing signals BS is searched for for every frequency.
[0191] For example, the vector notation of the correlation value K is carried out like a formula 36. The number t indicates the amount of phases to be in the correlation value ktf, and f are numbers which show a frequency among a formula 36.
[0192]
[Equation 36]

$$K=\begin{bmatrix} K_{11} & K_{12} \\ K_{21} & K_{22} \\ K_{31} & K_{32} \\ K_{41} & K_{42} \end{bmatrix}$$

[0193] First, a selection circuitry 1020 adds the square value (**ktf** 2) of an absolute value for every amount of phases respectively, and searches for the matrix KG which shows in a formula 37 while it calculates each absolute value of the correlation value ktf and calculates the square value (**ktf** 2) of each absolute value.
[0194]
[Equation 37]

$$KG=\begin{bmatrix} |K_{11}|^2+|K_{12}|^2 \\ |K_{21}|^2+|K_{22}|^2 \\ |K_{31}|^2+|K_{32}|^2 \\ |K_{41}|^2+|K_{42}|^2 \end{bmatrix}$$

[0195] Next, a selection circuitry 1020 searches for the request discrimination signal (henceforth the request discrimination signal MX) corresponding to the amount of phases of maximum for every frequency among Matrices BS while calculating maximum among Matrices KG.
[0196] Here, it is the request discrimination signal rf1 (1). -- rf1 (2) -- The vector notation of the matrix BS which shows rf1 (3 3theta) is carried out like a formula 38.
[0197]
[Equation 38]

$$BS=\begin{bmatrix} rf_1(1) & rf_1(2) & rf_1(3) \\ rf_1(1\ \theta) & rf_1(2\ \theta) & rf_1(3\ \theta) \\ rf_1(1\ 2\theta) & rf_1(2\ 2\theta) & rf_1(3\ 2\theta) \\ rf_1(1\ 3\theta) & rf_1(2\ 3\theta) & rf_1(3\ 3\theta) \end{bmatrix}$$

[0198] as the maximum of for example, the matrix KG -- [-- the time of ** k21 ** 2+ ** k22 ** 2] being chosen -- the inside of a formula 38 -- as the request discrimination signal MX for

every frequency (i) -- [-- rf1 (12theta) rf1 (2 2theta) and rf1(3 2theta)] are chosen. Furthermore, as request discrimination signals other than the request discrimination signal MX for every frequency (i) are shown in a formula 39 among formulas 38, it considers as the request processing signal BA. However, the request processing signal BA of a formula 39 shows an example as which [rf1 (1 2theta) rf1 (2 2theta) and rf1(3 2theta)] were chosen as a request discrimination signal MX (i).
[0199]
[Equation 39]

$$BA=\begin{bmatrix} rf_1(1) & rf_1(2) & rf_1(3) \\ rf_1(1\ \theta) & rf_1(2\ \theta) & rf_1(3\ \theta) \\ rf_1(1\ 3\theta) & rf_1(2\ 3\theta) & rf_1(3\ 3\theta) \end{bmatrix}$$

[0200] In addition, hereafter, in order to give explanation simply, as shown in a formula 40, the vector notation of the request processing signal BA (i) is carried out, and as shown in a formula 41, the vector notation of the request discrimination signal MX (i) is carried out. The number t indicates the amount of phases to be in the correlation value batf, and f are numbers which show a frequency among a formula 40. In mxt, t is a number which shows the amount of phases among a formula 41.
[0201]
[Equation 40]

$$BA(i)=\begin{bmatrix} ba_{11}(i) & ba_{21}(i) & ba_{31}(i) \\ ba_{12}(i) & ba_{22}(i) & ba_{32}(i) \\ ba_{13}(i) & ba_{23}(i) & ba_{33}(i) \end{bmatrix}$$

[0202]
[Equation 41]

$$MX(i)=\begin{bmatrix} mx_1 & mx_2 & mx_3 \end{bmatrix}$$

[0203] In addition, hereafter, as shown in a formula 42, the vector notation of discrimination signal X (i)' is carried out. However, M of ftMf in a formula 42 shows the number of an antenna element with the natural number, and f shows a frequency.
[0204]
[Equation 42]

$$X(i)'=\begin{bmatrix} ft_{11}(i) & ft_{12}(i) & ft_{13}(i) \\ ft_{21}(i) & ft_{22}(i) & ft_{23}(i) \end{bmatrix}$$

[0205] Next, the matrix-of-correlation presumption machine 1031 combines discrimination signal X (i)' and the request processing signal BA, and it asks for the instant input matrices RXMXM1, RXMXM2, and RXMXM3 in each time of day in Matrix XM with a formula 44, a formula 45, and a formula 46 while it generates the matrix XM shown in a formula 43. Based on a formula 47, the instant input matrices RXMXM1, RXMXM2, and RXMXM3 are equalized, and the estimate RXMXM of a matrix of correlation is calculated.
[0206]
[Equation 43]

$$XM(i)=\begin{bmatrix} X'(i) \\ BA(i) \end{bmatrix}=\begin{bmatrix} ft_{11}(i) & ft_{12}(i) & ft_{13}(i) \\ ft_{21}(i) & ft_{22}(i) & ft_{23}(i) \\ ba_{11}(i) & ba_{21}(i) & ba_{31}(i) \\ ba_{12}(i) & ba_{22}(i) & ba_{32}(i) \\ ba_{13}(i) & ba_{23}(i) & ba_{33}(i) \end{bmatrix}$$

[0207]
[Equation 44] RXMXM1=XM(1) and XM (1) H [0208]
[Equation 45] RXMXM2=XM(2) and XM (2) H [0209]
[Equation 46] RXMXM3=XM(3) and XM (3) H [0210]
[Equation 47]
RXMXM= (RXMXM1+RXMXM2+RXMXM3)/3, next the inverse-matrix computing element 1032 calculate inverse-matrix RXMXM-1 of the estimate RXMXM of a matrix of correlation. Moreover, the correlation vector presumption machine 1033 searches for discrimination signal X (i)' and the instant correlation vectors [in / as shown in a formula 48, a formula 49, and a formula 50 using the request discrimination signal MX and the request discrimination signal BA / each time of day] rxmb1, rxmb2, and rxmb3.
[0211] Next, based on a formula 51, the correlation vector presumption machine 1033 equalizes the instant correlation vectors rxmb1, rxmb2, and rxmb3 on a frequency, and calculates the correlation vector estimate rxmb.
[0212]
[Equation 48] rxmb1=XM(1) and MX (1) H [0213]
[Equation 49] rxmb2=XM(2) and MX (2) H [0214]
[Equation 50] rxmb3=XM(3) and MX (3) H [0215]
[Equation 51] It outputs "w1* w2*" to multipliers 201 and 202 among the multiplication results Z at it, respectively while matrix multiplication of the matrix multiplication machine 1034 is carried out to the rxmb= (rxmb1+rxmb2+rxmb3) / 3 last and it asks it for the multiplication result Z with the estimate RXMXM of a matrix of correlation, and the correlation vector estimate rxmb, as shown in a formula 52. In addition, the inside of a formula 51, -a1 - a2 - a3 -a4 are the signal weight stated to the above-mentioned 3rd operation gestalt.
[0216]
[Formula 52]
It can Z=[w1* w2*-a1 -a2 -a3 -a4] T Come, and are alike. More multipliers 201 and 202 It asks for a matrix product (w1*FT1 (i)) and a matrix product (w2*FT2 (i)), respectively, and by the adder (sigma) 300, a matrix product (w1*FT1 (i)) and (w2*FT2 (i)) are added for every frequency, and inner product signal WHX (i)' is called for.
[0217] The antenna weight w1 and w2 are updated so that the component except the request processing signal BA and the request discrimination signal MX may be oppressed among inner product signal WHX (i)' here. This prevents oppression with the request processing signal BA and the request discrimination signal MX without the need for oppression, and as substantially as the above-mentioned 1st and 2nd operation gestalt, since the signal component which originally has the need for oppression similarly can be oppressed, the Nur point can be formed in an effective target. Therefore, useless consumption of the degree of freedom of the adaptive array antenna of an SMI method can be held down.
[0218] For example, as shown in [alpha] drawing 22 , directivity can be formed by antenna elements 11 and 12.
[0219] That is, delay-GI outside signals other than the request processing signals BA and MX are oppressed among inner product signal WHX (i)', without oppressing the request discrimination signal MX. However, if a delay-GI outside signal and the request processing signal BA are received from the same, both a delay-GI outside signal and the request processing signal BA will be oppressed. Thus, among inner product signal WHX (i)', although the request discrimination signal MX is not oppressed and is left behind, the request processing signal BA may be oppressed depending on a receive direction.
[0220] Furthermore, the component of the request discrimination signal MX is left behind at least among inner product signal WHX (i)' by the antenna weight w1 and renewal of w2, and it is obtained. Here, since correlation with discrimination signal X (i)' is the largest signal among the request processing signals BS like ****, a signal with big receiving level can acquire the request discrimination signal MX as a component of the request discrimination signal MX among discrimination signal X (i)' by leaving behind the component of the request discrimination signal MX. Therefore, it can restore to the component of the request discrimination signal MX good.

[0221] In the above-mentioned 11th operation gestalt, the FFT circuits 801 and 802 are adopted and adaptive AREANTENA of an SMI method is constituted. In addition, the FFT circuits 801 and 802 Although explained per [which carries out FFT processing of the receiving OFDM signal x1 (i), and asks for the antenna weight w1 and w2 based on the signal on this frequency shaft by which FFT processing was carried out, respectively] example, you may make it be not only this but the following.
[0222] That is, without adopting the FFT circuits 801 and 802, adaptive AREANTENA of an SMI method is constituted, the receiving OFDM signal x1 (i) is replaced with the signal on the frequency shaft which carried out FFT processing, the receiving OFDM signal x1 on a time-axis (i) is adopted, and you may make it ask for the receiving OFDM signal x1(i) antenna weight w1 and w2 on a time-axis.
(The 11th operation gestalt) With the **** 11 operation gestalt, as shown in drawing 22 , low pass filters (LPF) 1040 and 1041 are added to the configuration which the above-mentioned 10th operation gestalt shows.
[0223] In drawing 22 , a low pass filter 1040 searches for the discrimination signal LF 1 of a narrow-band {=ft1 (1), ft1 (2)} based on discrimination signal ft1(1) -ft1 from the FFT circuit 801 (3). With this, a low pass filter 1040 searches for the discrimination signal LF 2 of a narrow-band {=ft2 (1), ft2 (2)} based on discrimination signal ft2(1) -ft2 from the FFT circuit 802 (3).
[0224] By this, a low pass filter 1040 will output the discrimination signal LF of the narrow-band shown in a formula 53. That is, a low pass filter 1040 outputs the discrimination signals LF1 and LF2 of a narrow-band by taking out only the component of a predetermined frequency band among discrimination signal ft1(1) -ft1(3) ft2(1) -ft(s)2 (3).
[0225]
[Equation 53]

$$LF=\begin{bmatrix} LF_1 \\ LF_2 \end{bmatrix}=\begin{bmatrix} ft_1(1) & ft_1(2) \\ ft_2(1) & ft_2(2) \end{bmatrix}$$

[0226] Moreover, it connects between the FFT circuit 83 and the phase revolution machine 1000, and a low pass filter 1041 searches for the discrimination signal rLF of a narrow-band {=rf1 (1), rf1 (2)} based on the request discrimination signal rf1 from the FFT circuit 83 (1), rf1 (2), and rf1 (3). That is, a low pass filter 1041 outputs the discrimination signal rf1 of a narrow-band (1), and rf1 (2) by taking out only the component of a predetermined frequency band among the request discrimination signal rf1 (1), rf1 (2), and rf1 (3).
[0227] Next, only four sorts of amounts of phases (0 degree, theta**, 2theta**, 3theta**) carry out revolution processing of the request discrimination signal rf1 (1), and the phase revolution machine 1000 outputs these request discrimination signals rf1 (1 theta), rf1 (1 2theta), and rf1 (1 3theta) by which revolution processing was carried out, and the request discrimination signal rf1 (1).
[0228] Furthermore, only four sorts of amounts of phases (0 degree, theta**, 2theta**, 3theta**) carry out revolution processing of the request discrimination signal rf1 (2), and the phase revolution machine 1000 outputs these request discrimination signals rf1 (2 theta), rf1 (2 2theta), and rf1 (2 3theta) by which revolution processing was carried out, and the request discrimination signal rf1 (2).
[0229] In addition, hereafter, request discrimination signal rf1(1) -rf1 (1 3theta) and rf1(2) -rf1 (2 3theta) are made into the request processing signal LBS, as shown in a formula 54.
[0230]
[Equation 54]

$$LBS=\begin{bmatrix} rf_1(1) & rf_1(2) \\ rf_1(1\ \theta) & rf_1(2\ \theta) \\ rf_1(1\ 2\theta) & rf_1(2\ 2\theta) \\ rf_1(1\ 3\theta) & rf_1(2\ 3\theta) \end{bmatrix}$$

[0231] next -- **** -- 11 -- operation -- a gestalt -- correlator -- 1010 -- the above -- the -- ten -- operation -- a gestalt -- having stated -- a request -- processing -- a signal -- BS -- replacing -- a request -- processing -- a signal -- LBS -- discrimination -- a signal -- X -- (-- i --) -- ' -- replacing -- a narrow-band -- discrimination -- a signal -- rLF -- correlation -- a value -- K -- ' -- asking . moreover -- a selection circuitry -- 1020 -- the above -- the -- ten -- operation -- a gestalt -- substantial -- the same -- correlation -- a value -- K -- ' -- being based -- a request -- processing -- a signal -- LBS -- inside -- a narrow-band -- discrimination -- a signal -- rLF -- correlation -- most -- being large -- a frequency -- every -- a request -- discrimination -- a signal -- MX -- ' -- asking . Furthermore, it asks for request processing signal BA' other than request processing signal MX' among the request processing signals LBS.

[0232] Next, in a computing element 1030, while it replaces with discrimination signal X (i)', and the discrimination signal rLF of a narrow-band is inputted, replacing with the request processing signal MX and inputting request processing signal MX', it replaces with the request processing signal BA, and request processing signal BA' is inputted.

[0233] Then, the matrix-of-correlation presumption machine 1031 calculates inverse-matrix RXMXM-1 of the estimate RXMXM of a matrix of correlation while calculating [gestalt / above-mentioned / 10th operation] the estimate RXMXM of a matrix of correlation substantially similarly based on the discrimination signal rLF of a narrow-band, and request processing signal MX' with the correlation vector presumption machine 1033 and the inverse-matrix computing element 1032.

[0234] Moreover, the correlation vector estimate rxmb is calculated using the discrimination signal rLF of a narrow-band, request discrimination signal MX', and request discrimination signal BA' as substantially [the correlation vector presumption machine 1033] as the above-mentioned 10th operation gestalt similarly. Furthermore, with the matrix multiplication vessel 1034, matrix multiplication of the estimate RXMXM of a matrix of correlation and the correlation vector estimate rxmb is carried out, antenna weight w1 w2 are calculated, and it is outputted to multipliers 201 and 202, respectively.

[0235] Since the component except the request processing signal BA and the request discrimination signal MX is oppressed among inner product signal WHX (i)' by the above, the same effectiveness is substantially acquired with the above-mentioned 10th operation gestalt. Furthermore, since the component of request discrimination signal MX' is left behind at least among inner product signal WHX (i)' and it is obtained, it can restore to the component of the request discrimination signal MX good substantially similarly with the above-mentioned 10th operation gestalt.

[0236] Moreover, while replacing with the request processing signal BS and adopting the request processing signal LBS in the operation of the correlation value of correlator 1010, it replaces with discrimination signal X (i)', and the discrimination signal rLF of a narrow-band is adopted. Here, like ****, the request processing signal LBS has a narrow frequency domain compared with the request processing signal BS, and the discrimination signal rLF of a narrow-band has a frequency domain narrow [the signal] like **** compared with discrimination signal X (i)'. For this reason, the amount of operations of the correlation value of correlator 1010 can be reduced compared with the above-mentioned 10th operation gestalt.

[0237] Furthermore, since correlation value K' of correlator 1010, the request processing signal LBS, and the discrimination signal rLF of a narrow-band are adopted when a selection circuitry 1020 asks for request processing signal MX'BA', the amount of operations of a selection circuitry 1020 can be reduced compared with the above-mentioned 10th operation gestalt.

[0238] Moreover, when a computing element 1030 calculates antenna weight w1 w2, while replacing with discrimination signal X (i)' and adopting the discrimination signal rLF of a narrow-band, it replaces with the request processing signal MX, and request processing signal MX' is adopted. For this reason, the amount of operations of a computing element 1030 can be reduced compared with the above-mentioned 10th operation gestalt.

(The 12th operation gestalt) With a **** 12 operation gestalt, the low pass filters (LPF) 1040 and 1041 stated with the above-mentioned 11th operation gestalt are adopted, and it explains

per [which constitutes the adaptive array antenna of PI method] example. The configuration in this case is shown in drawing 23 .

[0239] The adaptive array antenna of PI method in a **** 12 operation gestalt consists of antenna elements 11 and 12, a generator 60, the FFT circuits 83, 801, and 802, multipliers 201 and 202, an adder (sigma) 300, a phase revolution machine 1000, low pass filters (LPF) 1040 and 1041, and computing-element 1030A. Computing-element 1030A has matrix-of-correlation presumption machine 1031A, inverse-matrix computing-element 1032A, and matrix multiplication machine 1034A. In addition, in drawing 23 , the same sign in drawing 1 , drawing 2 , and drawing 22 shows the same object.

[0240] First, like the above-mentioned 11th operation gestalt, while a low pass filter 1040 searches for the discrimination signal LF 1 of a narrow-band {=ft1 (1), ft1 (2)} based on discrimination signal ft1(1) -ft1 from the FFT circuit 801 (3) Based on discrimination signal ft2(1) -ft2 from the FFT circuit 802 (3), the discrimination signal LF 2 of a narrow-band {=ft2 (1), ft2 (2)} is searched for.

[0241] Next, the phase revolution machine 1000 searches for the request processing signal LBS shown in a formula 53 like the above-mentioned 11th operation gestalt based on the discrimination signal rLF of the narrow-band from a low pass filter 1041 {=rf1 (1), rf1 (2)}.

[0242] Next, it computing-element 1030A Sets and matrix-of-correlation presumption machine 1031A combines the discrimination signals LF1 and LF2 and the request processing signal LBS of a narrow-band, and while generating the matrix FB shown in a formula 55, the above-mentioned 10th operation gestalt and the substantial estimate [in / similarly / Matrix FB] RFBFB of a matrix of correlation are calculated.

[0243]

[Equation 55]

$$FB = \begin{bmatrix} LF_1 \\ LF_2 \\ LBS \end{bmatrix} = \begin{bmatrix} ft_1(1) & ft_1(2) \\ ft_2(1) & ft_2(2) \\ rf_1(1) & rf_1(2) \\ rf_1(1\ \theta) & rf_1(2\ \theta) \\ rf_1(1\ 2\theta) & rf_1(2\ 2\theta) \\ rf_1(1\ 3\theta) & rf_1(2\ 3\theta) \end{bmatrix}$$

[0244] Next, inverse-matrix computing-element 1032A calculates inverse-matrix RFBFB-1 of the estimate RFBFB of a matrix of correlation. Furthermore, matrix multiplication machine 1034A outputs antenna weight w1 w2 to multipliers 201 and 202 among multiplication result Z', respectively while asking for multiplication result Z' using the formula showing in a formula 56. In addition, the inside of a formula 55, -a1 -a2-a3 - a4 is the signal weight AH stated to the above-mentioned 9th operation gestalt.

[0245] Here, antenna weight w1 w2 are updated so that power of the component except the request processing signal LBS may be made into min among inner product signal [of an adder circuit 300] WHX (i)'.

[0246]

[Equation 56]

$$\begin{aligned} Z' &= [1 \quad 0 \quad 0 \quad 0]^T \times R_{FBFB}^{-1} \\ &= [w_1^* \ w_2^* \ -a_1 \ -a_2 \ -a_3 \ -a_4]^T \end{aligned}$$

Furthermore, when computing-element 1030A calculates antenna weight w1 w2, while the discrimination signal rLF of a narrow-band is adopted, the request processing signal LBS is adopted. The frequency band of the discrimination signal rLF of a narrow-band is narrow here compared with the frequency band of discrimination signal X (i)' stated with the above-mentioned 10th operation gestalt, and the frequency band of the request processing signal LBS is narrow compared with the frequency band of the request processing signal BS stated with the above-mentioned 10th operation gestalt. Therefore, computing-element 1030A can reduce the

amount of operations compared with the time of using discrimination signal X (i)' and the request processing signal BS.
[0247] In addition, if it is two or more pieces as the number of antenna elements in operation of this invention, it is good without limit.
[0248] Furthermore, in carrying out frequency discrimination of the various signals, the example which adopted FFT processing was explained with each above-mentioned operation gestalt, but various kinds of frequency discrimination processings, such as not only this but DFT processing, may be adopted.

[Translation done.]

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2.**** shows the word which can not be translated.
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TECHNICAL FIELD

[Field of the Invention] This invention relates to an adaptive array antenna.

[Translation done.]

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PRIOR ART

[Description of the Prior Art] In recent years, the various proposals of the adaptive array antenna of the MMSE method which receives the input signal of a rectangular cross multi-carrier method are made. First, the outline of the signal (the signal of a rectangular cross multi-carrier method is hereafter called OFDM signal) of a rectangular cross multi-carrier method is explained with reference to drawing 25 and drawing 26 .
[0003] As shown in drawing 25 , the OFDM signal consists of a data signal and a preamble signal before this data signal. A preamble signal is a signal which arranged two or more pilot symbols (known signal) on the frequency shaft. A data signal consists of two or more OFDM symbols by which time multipled was carried out, and an OFDM symbol consists of a guard interval GI before an effective symbol and this effective symbol.
[0004] the guard interval GI -- an effective symbol -- the predetermined period part on [inner] the backside is copied. Therefore, if the time delay of the delay signal over a desired OFDM signal is shorter than the period TG of the guard interval GI when the sum of a desired OFDM signal and a desired delay signal is received as an input signal as shown in drawing 26 , data (for example, QPSK symbol) can restore an input signal by FFT processing (frequency discrimination processing).
[0005] Next, the adaptive array antenna of an MMSE (Minimum Mean Square Error) method is explained with reference to drawing 23 . Drawing 27 shows the outline configuration of the adaptive array antenna of an MMSE method. The adaptive array antenna of an MMSE method is an antenna element 11. -- They are 1M and a multiplier 21. -- It consists of 2M, the adder (sigma) 30, an MMSE computing element 40, an adder 50, and a generator 60. In addition, M is the natural number.
[0006] Antenna element 11 -- 1M receive an OFDM signal through an electric wave, and output the receiving OFDM signal X (i), respectively. Here, the receiving OFDM signal X (i) can be expressed with a formula 1. T shows transposition. i shows time of day.
[0007]
[Equation 1]
X(i) =[-- x1(i) x2(i) -- [ ] -- xM (i) --] -- T -- this sake -- antenna element 11 --1M -- respectively -- the receiving OFDM signal x1 (i), x2 (i), and -- xM (i) is outputted. Moreover, the MMSE computing elements 50 are multipliers 21 and 22. -- Multiplication is carried out to each of 2M at the antenna weight WH.
[0008] Here, the antenna weight WH can be expressed with a formula 2. H is complex-conjugate transposition.
[0009]
[Equation 2] A multiplier 20 carries out the multiplication of the receiving OFDM signal x1 (i) to antenna weight w1*, and outputs a multiplication signal (w1*x1(i)), and a multiplier 21 carries out the multiplication of the receiving OFDM signal x2 (i) to antenna weight w2*, and outputs a multiplication signal (w2*x2 (i)) to a W=[w1 w2 -- wM] T concrete target. Multiplier 2M carry out the multiplication of the receiving OFDM signal XM (i) to antenna weight wM*, and output a multiplication signal (wM*xM (i)).
[0010] An adder (sigma) 30 is a multiplication signal (w1*x1(i)) and a multiplication signal (w2*x2

(i)). -- The inner product signal WHX (i) which shows the inner product of the antenna weight W and the receiving OFDM signal X (i) is searched for by adding a multiplication signal (wM*xM (i)). a generator 60 memorizes a reference sign r0 (i) beforehand, and outputs this reference sign r0 (i) to an adder 50, and an adder 50 asks for error [of a reference sign r0 (i) and the inner product signal WHX (i)] e (i) -- {-- e(i) =r0(i)- WHX (i) --} . The MMSE computing element 40 updates the antenna weight W so that this error e (i) may be made small by considering the receiving OFDM signal X (i) and error e (i) as an input, and it is multipliers 21 and 22 about that antenna weight W. -- It outputs to 2M.

[0011] Here, the delay signal except a request known signal etc. can be oppressed among the receiving OFDM signals X (i) by adopting a request known signal (for example, preamble signal on a time-axis) as a reference sign r0 (i). Incidentally, in the adaptive array antenna of an MMSE method, the number of the known signals (null point) which can be oppressed is prescribed by the number of antenna elements, and it is (the number of antenna elements). - It is "1." Hereafter, the number of the known signals (null point) which can be oppressed is called degree of freedom.

[Translation done.]

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TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] By the way, in the adaptive array antenna of an MMSE method, although the time delay of the delay signal over a request known signal can restore data (the data 1 in drawing 26 - data 4) from an input signal if it is shorter than the period TG of the guard interval GI when the sum of a request known signal and its delay signal is received as an input signal like ****, the delay signal (henceforth the delay signal in GI) concerned will be oppressed.
[0013] It becomes impossible thus, to compound two or more signals and to raise the receiving engine performance by there being no need of oppressing and oppressing the delay signal in GI which can be restored and compounded.
[0014] moreover, null [in / in order to oppress the delay signal in GI / an adaptive array antenna] -- the delay signal delayed for the delay signal in GI since a point would be formed -- like -- original -- null -- the signal which should form a point -- null -- there is a problem of it becoming impossible to form a point. That is, the degree of freedom of an adaptive array antenna will be consumed vainly.
[0015] This invention aims at offering the adaptive array antenna which held down useless consumption of a degree of freedom in view of the above.

[Translation done.]

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MEANS

[Means for Solving the Problem] In order to attain the above-mentioned object, this invention in invention according to claim 1 The antenna multiplication means which carries out the multiplication of each antenna weight to the input signal received by two or more antenna elements (11 -- 1M) and two or more antenna elements (21 -- 2M), An addition means by which antenna weight adds each input signal by which multiplication was carried out, and outputs an addition signal (30), A reference calculation means to ask for a reference sign from the 1st known signal and the 2nd known signal (51-53, 51A, 53A), It is characterized by having an updating means (40A, 41) to update antenna weight according to the input signal, reference sign, and addition signal which were received by two or more antenna elements.
[0017] Here, a reference sign is computed from the 1st and 2nd known signals, and an updating means updates antenna weight according to a reference sign and the above-mentioned input signal concerned, the 2nd known signal, and an addition signal. For this reason, an updating means can oppress the component except the 1st and 2nd known signals by renewal of antenna weight among the input signals received by two or more antenna elements. Therefore, since oppression of the 2nd known signal is prevented and a signal component with the need for oppression can originally be oppressed when oppression of the 2nd known signal is unnecessary, the Nur point can be formed in an effective target. For this reason, useless consumption of the degree of freedom of an adaptive array antenna is held down.
[0018] Moreover, since the component except the 2nd known signal is oppressed among [1st] input signals, the composite signal of the 1st and 2nd known signals can be acquired among input signals. Here, like invention according to claim 2, the 2nd known signal can acquire a good recovery signal, when it is the delay signal which carried out predetermined period delay to said 1st known signal and gets over using the composite signal of the 1st and 2nd known signals compared with the case where it restores only to the 1st known signal.
[0019] Furthermore, you may make it have a delay means (80) to carry out predetermined period delay of the 1st known signal, and to search for the 2nd known signal like invention according to claim 3. Moreover, the 2nd known signal is not prepared beforehand but you may make it search for the 2nd known signal according to an input signal.
[0020] Like invention according to claim 4, namely, two or more antenna elements The signal which has the component of the 1st known signal and the component of the 2nd known signal is received as an input signal, respectively. Based on the input signal received by two or more antenna elements, it has a time delay calculation means (100) to find the time delay of the component of the 2nd [to the component of the 1st known signal] known signal, and only a time delay delays a request known signal and you may make it a delay means search for the 2nd known signal.
[0021] Furthermore, a delay signal generation means by which only time amount which is different to the 1st known signal, respectively generates two or more delay signals for ******* like invention according to claim 5 (90), You may make it have the correlating detector (131a-134c) which performs correlation detection of each delay signal of a delay signal generation means, and said input signal, and a selection means (135a-136) to choose any of two or more delay signals they are as 2nd known signal based on the correlation detection of a correlating

detector.
[0022] Like invention according to claim 6, specifically a reference-sign calculation means The 1st known signal is added to the 2nd known signal with which the multiplication of the signal weight was carried out to the 2nd known signal, and the multiplication of this signal weight was carried out, and it asks for a reference sign. An updating means You may make it update signal weight according to the input signal and the 2nd known signal which were received by two or more antenna elements, a reference sign, and an addition signal.
[0023] An oppression means to add a return signal by invention according to claim 7 here in order to oppress the component of the known signal of [2nd] the addition signals of an addition means (129 130), It is characterized by having an addition signal delay means (121-124) only for a predetermined period to delay an addition signal and to generate a delay addition signal, and a multiplication means (125-128) to carry out the multiplication of said signal weight to a delay addition signal, and to ask for said return signal. Thereby, an oppression means oppresses the component of the 2nd known signal among addition signals, and can output only the component of the 1st known signal.
[0024] Two or more antenna elements [invention / according to claim 8] (11 -- 1M), A received frequency discrimination means to carry out frequency discrimination of the receiving OFDM signal received by two or more antenna elements, respectively, and to search for a discrimination signal (801-80M), The antenna multiplication means which carries out the multiplication of the antenna weight to each discrimination signal by which frequency discrimination was carried out (201-20M), An addition means by which antenna weight adds each discrimination signal by which multiplication was carried out, and outputs an addition signal (300), A request frequency judgment means to search for the request discrimination signal with which frequency discrimination of the request OFDM signal was carried out (84), A delay means to search for the delayed discrimination signal delayed to the request discrimination signal (90 83), A reference addition means to add a request discrimination signal to the delayed discrimination signal with which the multiplication of the signal weight was carried out to the delayed discrimination signal, and the multiplication of this signal weight was carried out, and to ask for a reference sign (510, 520, 530), According to each of said discrimination signal and said delayed discrimination signal, said addition signal is brought close to said reference sign. It is characterized by having an updating means (40B) to update said antenna weight and said signal weight so that the component except the both sides of said request discrimination signal and a delayed discrimination signal may be oppressed among said each discrimination signal.
[0025] Thus, an updating means updates antenna weight and signal weight so that the component except the both sides of a request discrimination signal and a delayed discrimination signal may be oppressed among each discrimination signal. For this reason, since oppression of a delayed discrimination signal is prevented and a signal component with the need for oppression can originally be oppressed when oppression of a delayed discrimination signal is unnecessary, the Nur point can be formed in an effective target. For this reason, useless consumption of the degree of freedom of an adaptive array antenna is held down.
[0026] Moreover, since an updating means updates antenna weight and signal weight so that the component except the both sides of a request discrimination signal and a delayed discrimination signal may be oppressed among each discrimination signal like ****, it can obtain the both sides of a request discrimination signal and a delayed discrimination signal among each discrimination signal. If it gets over using the both sides of such a request discrimination signal and a delayed discrimination signal, a good recovery signal will be acquired compared with the case where it gets over only by the request discrimination signal.
[0027] Two or more antenna elements [invention / according to claim 9] (11-14), A received frequency discrimination means to carry out frequency discrimination of the receiving OFDM signal received by said two or more antenna elements, respectively, and to search for a discrimination signal (801-804), The antenna multiplication means which carries out the multiplication of the antenna weight to said each discrimination signal by which frequency discrimination was carried out (201-204), An addition means by which said antenna weight adds each discrimination signal by which multiplication was carried out, and outputs an addition signal

(300), A delay means to search for the delay OFDM signal which carried out predetermined period delay to the request OFDM signal (80A), A request frequency judgment means by which the both sides of said request OFDM signal and said delay OFDM signal search for the request discrimination signal by which frequency discrimination was carried out (834), A reference addition means to carry out the multiplication of the signal weight to said request discrimination signal, and to ask for a reference sign (530A), An addition reference-sign calculation means to add said reference sign and said addition signal, and to ask for an addition reference sign (510A), It is characterized by having an updating means (42) to update said antenna weight and said signal weight so that power of the component except said request discrimination signal may be made small among said addition reference signs.

[0028] Thus, since an updating means updates antenna weight and signal weight so that power of the component except the component of request discrimination ****** may be made small among addition reference signs, it can make small power of the component except the component of a request discrimination signal among addition reference signs. Therefore, while oppression of the signal with which oppression of a request discrimination signal is prevented, namely, frequency discrimination of the request OFDM signal was carried out is prevented, oppression of the signal with which frequency discrimination of the delay OFDM signal was carried out is prevented.

[0029] For this reason, since a signal component with the need for oppression can originally be oppressed when oppression of the signal with which frequency discrimination of the delay OFDM signal was carried out is unnecessary, the Nur point can be formed in an effective target. For this reason, useless consumption of the degree of freedom of an adaptive array antenna is held down.

[0030] Moreover, you may make it have a generation means (60) to generate the preamble signal with which the known signal was arranged on the frequency shaft as said request OFDM signal like invention according to claim 10. Furthermore, like invention according to claim 11, a received frequency discrimination means may carry out the thump rig of the receiving OFDM signal, each sampling signal may be acquired, said discrimination signal may be searched for according to each sampling signal, and you may make it a time delay be the predetermined multiple of the period of a sampling.

[0031] Furthermore, in invention according to claim 12, a delay means is characterized by outputting one delayed discrimination signal and said delayed discrimination signal of the request number. Thereby, like invention according to claim 1, an updating means can update said each antenna weight and signal weight so that the component except said request discrimination signal and the delayed discrimination signal of the request number may be oppressed among said each discrimination signal.

[0032] Furthermore, in invention according to claim 13, the request number of a delayed discrimination signal is characterized by being the maximum number decided by the guard interval period of the data signal of a request OFDM signal, and the period of a sampling. Thereby, further, since oppression of many delayed discrimination signals can be prevented, useless consumption of the degree of freedom of an adaptive array antenna can be held down effectively. In addition, the maximum number of a delayed discrimination signal is {(period of a guard interval period / sampling) -1}.

[0033] In invention according to claim 14, a reference-sign calculation means A means to carry out the multiplication of the signal weight to said 1st and 2nd known signals, and to ask for said reference sign (53A), It has a means (51A) to add said reference sign and said addition signal, and to ask for an addition reference sign. Said updating means (41) It is characterized by updating said antenna weight and said signal weight so that power of the component except said 1st and 2nd known signals may be made small among said addition reference signs.

[0034] Thus, since an updating means (41) updates antenna weight and signal weight so that power of the component except the 1st and 2nd known signals may be made small among addition reference signs, it can make small power of the component except the 1st and 2nd known signals among addition reference signs. For this reason, control of the 1st and 2nd known signals can be prevented, and since a signal component with the need for oppression can

originally be oppressed when control of the 2nd known signal is unnecessary, the Nur point can be formed in an effective target.
[0035] Two or more antenna elements [invention / according to claim 15] (11-14), The antenna multiplication means which carries out the multiplication of each antenna weight to the input signal received by said two or more antenna elements (21--24), An addition means by which said antenna weight adds each input signal by which multiplication was carried out, and outputs an addition signal (30), A received signalling frequency output means to output the received signalling frequency which shows the component of a narrow frequency band compared with the frequency band of these input signals among the input signals received by said two or more antenna elements, respectively (420-423), A known signalling frequency output means to output the known signalling frequency which shows the component of said narrow frequency band among known signals (424), A delay means to search for the delay signalling frequency which carried out predetermined period delay to said known signalling frequency (80A), A reference-sign calculation means to carry out the multiplication of the signal weight to said delay signalling frequency and said known signalling frequency, and to ask for a reference sign (53A), An addition reference-sign calculation means to add said reference sign and said addition signal, and to ask for an addition reference sign (51A), It is characterized by having an updating means (41) to update said antenna weight and said signal weight so that power of the component except said delay signalling frequency and said known signalling frequency may be made small among said addition reference signs.
[0036] Thus, since an updating means updates antenna weight and signal weight so that power of the component except delay signalling frequency and known signalling frequency may be made small among addition reference signs, it can make small power of the component except delay signalling frequency and known signalling frequency among addition reference signs. For this reason, control of delay signalling frequency and known signalling frequency can be prevented, and since a signal component with the need for oppression can originally be oppressed when control of delay signalling frequency is unnecessary, the Nur point can be formed in an effective target.
[0037] Here, the count of updating of antenna weight and signal weight is decided by the frequency band of an input signal, and since it replaces with an input signal in renewal of antenna weight and signal weight and the known signalling frequency of a narrow frequency band is used for it like **** compared with the frequency band of an input signal, it can reduce the count of updating of antenna weight and signal weight.
[0038] Moreover, two or more antenna elements [invention / according to claim 16] (11 12), A received frequency discrimination means to carry out frequency discrimination of the receiving OFDM signal received by two or more antenna elements, respectively, and to search for a discrimination signal (801 802), The antenna multiplication means which carries out the multiplication of the antenna weight to each discrimination signal by which frequency discrimination was carried out (201 202), An addition means by which antenna weight adds each discrimination signal by which multiplication was carried out, and outputs an addition signal (300), A known frequency judgment means to carry out frequency discrimination of the known OFDM signal, and to search for a known discrimination signal (83), A phase revolution means only for each amount of phases to carry out a phase revolution to a known discrimination signal, and to search for the phase revolution known discrimination signal corresponding to each amount of phases (1000), A correlation means to take correlation with the phase revolution known discrimination signal corresponding to each amount of phases, and each discrimination signal, and to calculate the correlation value corresponding to each amount of phases (1010), While choosing a maximum correlation value among the correlation values corresponding to each amount of phases the phase revolution known discrimination signal corresponding to each amount of phases -- with a selection means (1020) to choose the response phase revolution known discrimination signal corresponding to a maximum correlation value inside While making small the component except the phase revolution known discrimination signal corresponding to each amount of phases among addition signals, it is characterized by having an updating means (1034) to update antenna weight so that it may leave a response phase revolution known

discrimination signal at least among addition signals.
[0039] Thus, an updating means updates the antenna weight which makes small the component except the phase revolution known discrimination signal corresponding to each amount of phases among addition signals. Therefore, the component except the phase revolution known discrimination signal corresponding to each amount of phases can be made small among addition signals. For this reason, control of the phase revolution known discrimination signal corresponding to each amount of phases can be prevented, and since a signal component with the need for oppression can originally be oppressed when control of the phase revolution known discrimination signal corresponding to each amount of phases is unnecessary, the Nur point can be formed in an effective target.
[0040] Furthermore, an updating means updates antenna weight so that it may leave the response phase revolution known discrimination signal corresponding to a maximum correlation value at least among addition signals. Therefore, it can leave the response phase revolution known discrimination signal corresponding to a maximum correlation value at least among addition signals.
[0041] Here, since a response phase revolution known discrimination signal is equivalent to the phase revolution known discrimination signal of a maximum-electric-power value among the phase revolution known discrimination signals corresponding to each amount of phases, it can acquire the big revolution known discrimination signal of a received-power value by leaving a response phase revolution known discrimination signal.
[0042] Two or more antenna elements [invention / according to claim 17] (11 12), A received frequency discrimination means to carry out frequency discrimination of the receiving OFDM signal received by two or more antenna elements, respectively, and to search for a discrimination signal (801 802), The antenna multiplication means which carries out the multiplication of the antenna weight to each discrimination signal by which frequency discrimination was carried out (201 202), An addition means by which antenna weight adds each discrimination signal by which multiplication was carried out, and outputs an addition signal (300), A narrow-band output means to output the narrow-band discrimination signal of a narrow frequency band among each discrimination signal compared with a discrimination signal, respectively (1040), A request frequency judgment means to carry out frequency discrimination of the known OFDM signal, and to search for a known discrimination signal (83), A known narrow-band output means to output the narrow-band known discrimination signal of a narrow frequency band among known discrimination signals compared with a known discrimination signal (1041), Only the amount of phases which is different to a narrow-band known discrimination signal, respectively carries out a phase revolution. A phase revolution means to search for the signal according to phase rotary valve of the narrow-band corresponding to each amount of phases (1000), A correlation means to take correlation with the signal according to phase rotary valve of the narrow-band corresponding to each amount of phases, and each discrimination signal, and to calculate the correlation value corresponding to each amount of phases (1010), While choosing a maximum correlation value among the correlation values corresponding to each amount of phases A selection means to choose the signal according to phase rotary valve of the narrow-band corresponding to a maximum correlation value among the signals according to phase rotary valve of each narrow-band (1020), While making small the component except the phase revolution known discrimination signal of the narrow-band corresponding to each amount of phases among addition signals, it is characterized by having an updating means (1033) to update so that it may leave at least the signal according to phase rotary valve of the narrow-band which corresponds among addition signals.
[0043] Thus, since an updating means updates the antenna weight which makes small the component except the phase revolution known discrimination signal of the narrow-band corresponding to each amount of phases among addition signals, it can make small the component except the phase revolution known discrimination signal of the narrow-band corresponding to each amount of phases among addition signals. For this reason, control of the phase revolution known discrimination signal of the narrow-band corresponding to each amount of phases can be prevented, and since a signal component with the need for oppression can

originally be oppressed when control of the phase revolution known discrimination signal of the narrow-band corresponding to each amount of phases is unnecessary, the Nur point can be formed in an effective target.

[0044] Furthermore, an updating means updates antenna weight so that it may leave the phase revolution known discrimination signal of the narrow-band corresponding to a maximum correlation value at least among addition signals. Therefore, it can leave the phase revolution known discrimination signal of the narrow-band corresponding to a maximum correlation value at least among addition signals.

[0045] Here, since said corresponding phase revolution known discrimination signal of a narrow-band is equivalent to the phase revolution known discrimination signal of a maximum-electric-power value among the phase revolution known discrimination signals corresponding to each amount of phases, it can acquire the big revolution known discrimination signal of a received-power value by leaving said corresponding phase revolution known discrimination signal of a narrow-band.

[0046] Here, since the signal according to phase rotary valve of a narrow-band is used when an updating means updates antenna weight, the amount of operations for updating can be reduced compared with invention according to claim 16.

[0047] Two or more antenna elements [invention / according to claim 18] (11 12), A received frequency discrimination means to carry out frequency discrimination of the receiving OFDM signal received by two or more antenna elements, respectively, and to search for a discrimination signal (801 802), The antenna multiplication means which carries out the multiplication of the antenna weight to each discrimination signal by which frequency discrimination was carried out (201 202), An addition means by which antenna weight adds each discrimination signal by which multiplication was carried out, and outputs an addition signal (300), A narrow-band output means to output the narrow-band discrimination signal of a narrow frequency band among each discrimination signal compared with a discrimination signal, respectively (1040), A request frequency judgment means to carry out frequency discrimination of the known OFDM signal, and to search for a known discrimination signal (83), A known narrow-band output means to output the narrow-band known discrimination signal of a narrow frequency band among known discrimination signals compared with a known discrimination signal (1041), The phase revolution means (1000) which carries out the phase revolution of the narrow-band known discrimination signal, and the inside of an addition signal, It is characterized by having an updating means (1030A) to update antenna weight so that power of the component except a narrow-band known discrimination signal and said narrow-band known discrimination signal by which the phase revolution was carried out may be made small.

[0048] Thus, since antenna weight is updated so that power of the component except the narrow-band known discrimination signal by which the phase revolution was carried out with the narrow-band known discrimination signal among addition signals may be made small, power of the component except a narrow-band known discrimination signal and said narrow-band known discrimination signal by which the phase revolution was carried out can be made small among addition signals. For this reason, control of a narrow-band known discrimination signal and said narrow-band known discrimination signal by which the phase revolution was carried out can be prevented, and since a signal component with the need for oppression can originally be oppressed when control of a narrow-band known discrimination signal and said narrow-band known discrimination signal by which the phase revolution was carried out is unnecessary, the Nur point can be formed in an effective target.

[0049] Here, since said narrow-band known discrimination signal by which the phase revolution was carried out and signal according to phase rotary valve of a narrow-band are used when an updating means computes antenna weight, the amount of operations for updating can be reduced.

[0050] Incidentally, the sign in the parenthesis of each above-mentioned means is an example which shows response relation with the concrete means of a publication to the operation gestalt mentioned later.

[0051]

[Embodiment of the Invention] (The 1st operation gestalt) The adaptive array antenna of the MMSE method which starts the 1st operation gestalt of this invention at drawing 1 is shown. In a **** 1 operation gestalt, the adaptive array antenna of an MMSE method shows the example which receives an OFDM signal. Drawing 1 is a block diagram about the outline configuration of the adaptive array antenna of an MMSE method. The adaptive array antenna of an MMSE method is an antenna element 11, as shown in drawing 1 . -- They are 1M (M is the natural number) and a multiplier 21. -- It consists of 2M, an adder (sigma) 30, MMSE computing-element 40A, adders 51 and 52, a multiplier 53, and generators 60 and 70. In drawing 1 , the same sign as the sign in drawing 18 shows the same object or a substantial same object.
[0052] A generator 60 generates the preamble signal r0 of an OFDM signal (i) as a request known signal, and this preamble signal r0 (i) is a signal with which two or more pilot symbols (known signal) were arranged on the frequency shaft.
[0053] A generator 70 generates the delay signal of U (U is the natural number) individual to the preamble signal r0 (i) as other known signals, and U delay signals have a different time delay to a preamble signal, respectively. However, each time delay of U delay signals over a preamble signal is short compared with the period TG of the guard interval GI of an OFDM symbol, and is hereafter set to delay signal R (i) which shows U delay signals in a formula 3.
[0054]
[Equation 3]
R(i) =[-- r1(i) r2(i) -- rU (i) --] -- < -- SUP>T, next a multiplier 53 output the multiplication signal {AHR (i)} which carries out the multiplication of the signal weight AH expressed to a formula 4 to delay signal R (i), and is shown in a formula 5.
[0055]
[Equation 4] A= [a1 a2 --aU] T [0056]
[Equation 5] AHR(i) =a1*r1(i)+a2*r2(i) -- aU*rU (i)
Next, an adder 52 adds the preamble signal r0 (i) and the multiplication signal AHR (i), and outputs an addition signal (r0(i)+AHR(i)). Here, an addition signal (r0(i)+AHR(i)) turns into a composite signal (reference sign) of the preamble signal r0 (i) and delay signal R (i). And an adder 51 asks for error [of an addition signal (r0(i)+AHR(i)) and the inner product signal WHX of an adder 30 (i)] e (i). Here, error e (i) can be expressed to a formula 6.
[0057]
[Equation 6] To e(i) =r0(i)+AHR(i)-WHX, next MMSE computing-element 40A The receiving OFDM signal X (i), delay signal R (i), and error e (i) are inputted. MMSE computing-element 40A for example, SMI (Sample Matrix Inversion) of an MMSE method, while updating the antenna weight W and outputting to a multiplier 21 and 22 --2M so that error e (i) may be made small based on law The signal weight A is updated and it outputs to a multiplier 53 so that error e (i) may be made small based on the SMI method of an MMSE method.
[0058] Thereby, as an inner product signal WHX of an adder 30, the component except preamble signal r0 (i), (request known signal), and delay signal R (i) (other known signals) becomes a repressed signal among the receiving OFDM signals X (i).
[0059] Here, the signal weight A is called for so that MMSE computing-element 40A may show the phase contrast and the amplitude difference of delay signal R (i) and a (the 2nd known signal) on the basis of the preamble signal r0 (i) and (the 1st known signal).
[0060] Hereafter, the description of a **** 1 operation gestalt is described. First, the time delay of delay signal R (i) to the preamble signal r0 can restore data (for example, QPSK data symbol) for the inner product signal WHX of an adder 30 by FFT processing (frequency discrimination), without oppressing delay signal R (i) among the receiving OFDM signals X (i) like ****, since it is short compared with the period TG of the guard interval GI.
[0061] That is, oppression of delay signal R (i) is unnecessary among the receiving OFDM signals X (i). So, with a **** 1 operation gestalt, a repressed signal is acquired for the component except the preamble signal r0 (i) and the delay signal AHR (i) among the receiving OFDM signals X (i) as an inner product signal WHX of an adder 30 like ****.
[0062] For this reason, since oppression of delay signal R (i) is prevented and a signal component with the need for oppression can originally be oppressed, the Nur point can be

formed in an effective target. Therefore, useless consumption of the degree of freedom of the adaptive array antenna of an MMSE method can be held down.
[0063] Moreover, since the addition signal (r0(i)+AHR(i)) of the preamble signal r0 (i) and delay signal R (i) is acquired, if it restores to this addition signal as an inner product signal WHX of an adder 30, a good recovery signal will be acquired compared with the case where it restores to the preamble signal r0 (i).
[0064] Here, the result of a simulation is shown in drawing 2 . An axis of abscissa is the receiving include angle [deg] of the received electric wave on the basis of the adaptive array antenna of an MMSE method among drawing 2 , and an axis of ordinate is an oppression ratio (dB). The chain line shows the result of the simulation which used the adaptive array antenna of the conventional MMSE method. A continuous line shows the result of the simulation which used the adaptive array antenna of the MMSE method of a **** 1 operation gestalt.
[0065] Although the delay signal in GI is oppressed in the adaptive array antenna of the conventional MMSE method so that drawing 2 may show, oppression of the delay signal in GI is prevented in the adaptive array antenna of the MMSE method of a **** 1 operation gestalt. However, the delay signal in GI is a delay signal which has a short time delay compared with Period (guard interval GI) TG to a request signal (preamble signal r0).
[0066] Below, the SMI algorithm of the MMSE method of MMSE computing-element 40A in a **** 1 operation gestalt is described. First, error e (i) shown in a formula 6 can be transformed, and error e (i) can be expressed like a formula 7.
[0067]
[Equation 7]

$$
\begin{aligned}
e(i) &= r_0(i) + R(i)A^H - W^H X \\
&= r_0(i) - \{W^H X - R(i)A^H\} \\
&= r_0(i) - Y^H Z(i)
\end{aligned}
$$

Y is the antenna weight W and weight including the both sides of the signal weight A here, as shown in a formula 8, and Z (i) is a signal including the both sides of the receiving OFDM signal X (i) and delay signal R (i), as expressed to a formula 9.
[0068]
[Equation 8] Y= [w1 w2 w3 -- wM-a1-a2-a3 ---aU] T [0069]
[Equation 9] Z -- = -- [-- x -- one -- (-- i --) -- -- x2 -- (-- i --) -- -- x -- three -- (-- i --) .... xM -- (-- i --) -- -- r -- one -- (-- i --) -- -- r -- two -- (-- i --) -- -- r -- three -- (-- i --) -- rU -- (-- i --) --] -- TSMI -- an algorithm -- an odor -- a formula -- ten -- being shown -- a performance index -- Q -- direct -- minimizing . However, alpha is the weighting constant of 0< alpha<=1.
[0070]
[Equation 10]

$$Q(i)=\sum_{i=1}^{G}\alpha^{G-i}|e(i)|^2$$

[0071] Furthermore, the gradient vector about the weight Y of a formula 7 is set with zero, and the least square of a performance index Q is obtained like a formula 11. This formula 11 shows the formula for updating weight Y (G). However, G is time amount (thump rig time amount), and G shows the count of updating of Weight Y (number of steps).
[0072]
[Equation 11]

$$Y(G)= B^{-1}(G)\,b(G)$$

[0073] Here, a formula 12 and a formula 13 are shown for B in a formula 11, and b.
[0074]
[Equation 12]

$$B=\sum_{i=1}^{G}\alpha^{G-i}Z(i)Z^H(i)$$

[0075]
[Equation 13]
$$b(G)=\sum_{i=1}^{G}\alpha^{G-i}Z(i)r_0^*(i)$$

[0076] (The 2nd operation gestalt) Although the example which adopted the generator 70 was explained with the above-mentioned 1st operation gestalt in order to generate delay signal R (i) and (U delay signals), you may make it generate delay signal R (i) using the preamble signal outputted not only from this but from the generator 60. The configuration in this case is shown in drawing 3 and drawing 4 .
[0077] Drawing 3 is the block diagram showing the configuration of the adaptive array antenna of the MMSE method of a **** 2 operation gestalt, and drawing 4 is drawing showing the detail of the delay circuit in drawing 3 (henceforth a delay circuit 80). With the **** 2 operation gestalt, as shown in drawing 3 , while the generator 60 shown in drawing 1 is deleted, the delay circuit 80 is adopted. In drawing 3 , the same sign as the sign in drawing 1 shows the same object or a substantial same object.
[0078] A delay circuit 80 is arranged between a generator 60 and a multiplier 53, and outputs delay signal R (i) stated with the above-mentioned 1st operation gestalt in response to the preamble signal outputted from the generator 60.
[0079] Specifically, a delay circuit 80 is the delay signal r1 (i) with which the series connection of the delay machines (Z-1) 801, 802, and 803 and the --80U is carried out, it is constituted, and the delay machines 801, 802, and 803 and --80U correspond, respectively as shown in drawing 4 , and r2 (i). -- rU (i) is outputted to MMSE computing-element 40A and a multiplier 53. Other actuation and effectiveness are the same as the above-mentioned 1st operation gestalt.
[0080] (The 3rd operation gestalt) Although the adaptive array antenna of an MMSE method explained the example which adopted the pudding AMBURU signal of an OFDM signal as a signal on a time-axis with the above-mentioned 1st and 2nd operation gestalt, you may make it adopt each discrimination signal which carried out FFT processing (frequency judgment) of the pudding bull signal of not only this but an OFDM signal. The configuration in this case is shown in drawing 5 - drawing 8 . It is ****** with which drawing 5 is drawing showing the configuration of the adaptive array antenna of a **** 3 operation gestalt, and drawing 6 indicates the detail configuration of the FFT circuit 83 in drawing 5 to be. Drawing 7 is drawing showing actuation of the delay circuit 90 of drawing 5 , and drawing 8 is drawing showing actuation of the FFT circuit in drawing 6 .
[0081] With the **** 3 operation gestalt, as shown in drawing 5 , MMSE arithmetic circuit 40B is replaced with and adopted as MMSE arithmetic circuit 40A in drawing 1 , and Multipliers 201-20M are replaced with and adopted as the multipliers 21-2M in drawing 1 . Multipliers 510-530 are replaced with and adopted as the multipliers 51-53 in drawing 1 . Furthermore, the FFT circuits 801-80M, and 83 and 84 are added. The FFT circuit 801 carries out FFT processing of the pudding AMBURU signal of the receiving OFDM signal x1 of an antenna element 11 (i). The FFT circuit 801 samples only N (N is the natural number) time as every [of the above-mentioned pudding AMBURU signal] effective symbol (refer to drawing 17) (analog to digital conversion), carries out FFT processing based on each sampling signal, and, specifically, is the discrimination signal ft1 for every frequency (1), and ft1 (2). -- ft1 (N) may be outputted. Here, they are the discrimination signal ft1 (1) and ft1 (2). -- ft1 (N) can be summarized and can be expressed with a formula 14. Moreover, N is the count of a sampling of the above-mentioned effective symbol, and is the point size of FFT of the above-mentioned effective symbol.
[0082]
[Equation 14] As substantially as the FFT circuit 801, similarly, the FT1(i) =[ft1(1) ft1(2) ft1(3) -- ft1 (N)] TFFT circuit 802 carries out FFT processing of the pudding AMBURU signal of the receiving OFDM signal x1 of an antenna element 11 (i), and is the discrimination signal ft2 for every frequency (1), and ft2 (2). -- ft2 (N) is outputted. Furthermore, the discrimination signal ft2 (1), ft2 (2) -- ft2 (N) is summarized and can be expressed with a formula 15.

[0083]
[Equation 15] FT2(i) =[ft2(1) ft2(2) ft2(3) —ft2 (N)] TFFT circuit 80M carry out FFT processing of the pudding AMBURU signal of the receiving OFDM signal xM of antenna element 1M (i) similarly substantially with the FFT circuit 801, and are the discrimination signal ftM for every frequency (1), and ftM (2). — ftM (N) is outputted. Furthermore, the discrimination signal ftM (1), ftM (2) — ftM (N) is summarized and can be expressed with a formula 16.
[0084]
[Equation 16] FTM(i) =[— ftM(1) ftM(2) ftM(3) — ftM (N) —] — T — here — a **** 3 operation gestalt — FT1 (i), FT2 (i), and — [0085] made into discrimination signal X (i)' as FTM (i) is summarized and it is shown in a formula 17
[Equation 17] X — (— i —) — ' — = — [— FT — one — (— i —) — — FT — two — (— i —) — FTM — (— i —) —] — T — next — a multiplier — 201 - 20 — M — the antenna weight WH — discrimination signal X (i)' — multiplication — carrying out . That is, a multiplier 201 obtains a result (w1*FT1 (i)) in quest of the product of antenna weight w1* and FT1 (i). A multiplier 202 obtains a result (w2*FT2 (i)) in quest of the product of antenna weight w2* and FT2 (i). Furthermore, multiplier 20M obtain a result (wM*FTM (i)) in quest of the product of antenna weight wM* and FTM (i).
[0086] next — an adder (sigma) — 300 — a multiplier — 201 - 20 — M — depending — a result (w1*FT1 (i)) — (— w — two — * — FT — two — (— i —) —) — (wM*FTM (i)) — a frequency — every — adding — things — an antenna — weight — W — discrimination — a signal — X — (— i —) — ' — an inner product — being shown — an inner product — a signal — WHX — (— i —) — ' — asking .
[0087] Incidentally, as inner product signal WHX (i)', as shown in a formula 18, the inner product signal of the N individual fx1(1) fx2(2) —fxM(N) is packed. Furthermore, for example, fx1 (1) can express an inner product signal with a formula 19, and the inner product signal fx2 (2) can be expressed with a formula 20. Furthermore, the inner product signal fxM (N) can be expressed with a formula 21.
[0088]
[Equation 18] WHX(i)'= [fx1(1) fx2(2) —fxM(N)] T [0089]
[Equation 19] fx1(1) =w1* and ft1 (1) +w2*, ft2 (1) — wM*, ftM (1)
[0090]
[Equation 20] fx2(2) =w1* and ft1 (2) +w2*, ft2 (2) — wM*, ftM (2)
[0091]
[Equation 21] fxM(N) =w1* and ft1 (N) +w2*, ft2 (N) — wM*, ftM (N)
Next, delay circuits 90 are the delay preamble signals OF (t+tS), OF (t+2, tS), and OF (t+3, tS) over this preamble signal r0 (i), in response to the fact that the preamble signal r0 of an OFDM signal (i) and the (request known signal) from a generator 60, as shown in drawing 6 . — OF (t+p-tS) is generated.
[0092] However, tS is the time amount which shows the sampling period of the FFT circuits 801-80M, and (p+1) is the count of the sampling at the time of sampling the guard interval GI of an OFDM symbol by time amount tS.
[0093] Thereby, they are the delay preamble signals OF (t+tS) and OF (t+2, tS). — OF (t+p-tS) has a time delay shorter than the guard interval period TG to the preamble signal r0 (i), respectively. Furthermore, as the number of a delay preamble signal, it is the maximum number defined with the guard interval period TG and a sampling period tS {p=(TG/tS)-1}.
[0094] Here the delay preamble signal OF (t+tS) As shown in drawing 7 , by the signal which delayed only time amount tS to the preamble signal r0 (i) the delay preamble signal OF (t+2, tS) It is the signal which delayed only time amount 2 tS to the preamble signal r0 (i), and the delay preamble signal OF (t+3, tS) is a signal which delayed only time amount 3 and tS to the preamble signal r0 (i). The delay preamble signal OF (t+p-tS) is a signal which delayed only time amount p-tS to the preamble signal r0 (i).
[0095] Next, the FFT circuits 83 are the delay preamble signals OF (t+tS), OF (t+2, tS), and OF (t+3, tS) from a delay circuit 90, as shown in drawing 6 . — Each effective symbol of OF (t+p-tS) is sampled with a sampling period tS in juxtaposition, and FFT processing is carried out by the

sampling signal. Specifically, the FFT circuits 83 are the FFT processing sections 831, 832, and 833. -- It has 83p, and as shown in drawing 8 , the FFT processing section 831 carries out FFT processing of the effective symbol of the delay preamble signal OF (t+tS) with a sampling period tS, and outputs delayed discrimination signal R (1). However, delayed discrimination signal R (1) can be expressed with a formula 22. This delayed discrimination signal R (1) has a signal component for every frequency.
[0096]
[Equation 22] R(1) = -- "-- f1(1) f1(2) f1 (3) -- f1 (N) -- " -- T -- the FFT processing section 832 outputs delayed discrimination signal R (2) shown in a formula 23 again by carrying out FFT processing of the effective symbol of the delay preamble signal OF (t+2, tS) with a sampling period tS, as shown in drawing 8 . This delayed discrimination signal R (2) has a signal component for every frequency. Furthermore, FFT processing section 83p outputs delayed discrimination signal R (p) shown in a formula 24 by carrying out FFT processing of the effective symbol of the delay preamble signal OF (t+p-tS) with a sampling period tS, as shown in drawing 8 . Delayed discrimination signal R (p) has a signal component for every frequency.
[0097]
[Equation 23] R -- (-- two --) -- = -- "-- f -- two -- (-- one --) -- -- f -- two -- (-- two --) -- -- f -- two -- (-- three --) -- f -- two -- (-- N --) -- " -- T -- [-- 0098 --]
[Equation 24] R -- (-- p --) -- = -- "-- fp -- (-- one --) -- -- fp -- (-- two --) -- -- fp -- (-- three --) -- fp -- (-- N --) -- " -- T -- next -- drawing 5 -- being shown -- FFT -- a circuit -- 84 -- drawing 8 -- being shown -- as -- the preamble signal r0 of the OFDM signal from a generator 60 (i) -- (-- = -- the effective symbol of OF (t)) is sampled with a sampling period tS, and FFT processing is carried out by these sampling signal. Thereby, the FFT circuit 84 outputs request discrimination signal r0 (i)', as shown in a formula 25. Request discrimination signal r0 (i)' has a signal component for every frequency.
[0099]
[Equation 25] r -- zero -- (-- i --) -- ' -- = -- "-- f -- zero -- (-- one --) -- -- f -- zero -- (-- two --) -- -- f -- zero -- (-- three --) -- f -- zero -- (-- N --) -- " -- T -- next -- a multiplier -- 530 -- the product of the signal weight AH and delayed discrimination signal R (i) -- taking -- an output signal {AHR (i)} -- outputting . However, the signal weight A in a **** 3 operation gestalt is shown in a formula 26. In addition, an output signal {AHR (i)} packs the output signal of N individual, and is written.
[0100]
[Equation 26] An adder 520 adds the output signal {AHR (i)} of a multiplier 530, and request discrimination signal r0 (i)' to an A=[a1 a2 --aP] T pan, and outputs an addition signal (r0(i)'+AHR (i)) to it. An adder 510 asks for error [with addition signal (r0(i)'+AHR(i)) and inner product signal / of an adder 30 / WHX (i)'] e (i).
[0101] Here, to MMSE computing-element 40B, discrimination signal X (i)', and delayed discrimination signal R (i) and error e (i) are inputted, and MMSE computing-element 40B updates the signal weight A while updating the antenna weight W like the above-mentioned 1st and 2nd operation gestalt so that error e (i) may be made small based on the SMI method of an MMSE method. Thereby, as inner product signal [of an adder 300] WHX (i)', the component except request discrimination signal r0 (i)' (request known signal) and delayed discrimination signal R (i) (other known signals) becomes a repressed signal among discrimination signal X (i)'. Thereby, the same effectiveness is substantially acquired with the above-mentioned 1st and 2nd operation gestalt.
[0102] In addition, at the above-mentioned 3rd operation gestalt, they are the delay preamble signals OF (t+tS), OF (t+2, tS), and OF (t+3, tS). -- Although the example which obtained delayed discrimination signal R (i) based on OF (t+p-tS) was explained, delayed discrimination signal R (i) may be obtained not only based on this but based on request discrimination signal r0 (i)'.
[0103] (The 4th operation gestalt) Although the adaptive array antenna of an MMSE method explained the example which receives an OFDM signal with the above-mentioned 1-3rd operation gestalt, the adaptive array antenna of not only this but an MMSE method may be

applied to a CDMA communication link. The configuration in this case is shown in drawing 9 .
[0104] The matched filter 100 and the RAKE composition machine 110 are added and constituted from drawing 9 by the circuit shown in drawing 3 . Furthermore, it replaces with the delay circuit 80 shown in drawing 3 , and delay circuit 80A is adopted. In drawing 9 , the same sign as the sign in drawing 1 shows the same object or a substantial same object. however -- each -- ANTENANA component 11 --1M -- an OFDM signal -- replacing with -- a CDMA signal -- receiving -- the receiving CDMA signal x1 (i), x2 (i), and -- xM (i) is outputted.
[0105] Next, actuation of a **** 4 operation gestalt is explained with reference to drawing 10 . Hereafter, four antenna elements 11-14 are adopted, and the example to which antenna elements 11-14 output each is explained. A matched filter 100 performs correlation detection with the pilot signal (known signal) (i) r0 from each and a generator 60 for the receiving CDMA signal x1 (i), x2 (i), x3 (i), and x4 (i) in juxtaposition.
[0106] concrete -- a matched filter 100 -- the 1- it has the 4th matched filter section (not shown). The 1st matched filter section carries out correlation detection of the receiving CDMA signal x1 (i) and a pilot signal r0 (i), and outputs a correlation signal (refer to drawing 10 (a)), and the 2nd matched filter section considers correlation detection with a pilot signal r0 (i) as receiving CDMA signal x2 (i), and outputs a correlation signal (refer to drawing 10 (b)).
[0107] The 3rd matched filter section carries out correlation detection of the receiving CDMA signal x3 (i) and a pilot signal r0 (i), and outputs a correlation signal (refer to drawing 10 (c)), and the 4th matched filter section carries out correlation detection of the receiving CDMA signal x4 (i) and a pilot signal r0 (i), and outputs a correlation signal (refer to drawing 10 (d)). However, by drawing 10 (a) - (d), an axis of ordinate shows a correlation value, and an axis of abscissa shows time amount by it.
[0108] here -- a matched filter 100 -- the 1- the correlation signal from the 4th matched filter section is added, and the delay information on the basis of the time of the input of a pilot signal r0 (i) and a (request signal) is acquired based on the addition result. This delay information shows the delay signal of a time delay shorter than desired time amount among receiving CDMA signal x1(i) -x4(i). The example shown in drawing 10 (e) shows the example of ** from which td1, td2, td3-td6 are obtained as delay information. Then, using the delay information td1-td6, delay circuit 80A outputs delay signal R (i) and (other known signals), as shown in drawing 10 (f).
[0109] That is, delay circuit 80A is r0 (t+td1), r0 (t+td2), and r0 (t+td2). -- r0 (t+td6) is outputted. For example, to a pilot signal r0 (i), only the time delay td1 is delayed and, as for r0 (t+td2), only the time delay td2 is delayed by r0 (t+td1) to a pilot signal r0 (i). As for r0 (t+td6), only the time delay td6 is delayed to a pilot signal r0 (i). Other actuation is substantially [as the circuit shown in drawing 3] the same.
[0110] By the above, it is the receiving CDMA signal x1 (i) as an inner product signal WHX from an adder (sigma). -- A repressed signal is acquired for the component except a pilot signal r0 (i) (request signal) and its delay signals r0 (t+td1)-r0 (t+td6) (other known signals) among xM(s) (i). And the RAKE composition machine 110 will perform a RAKE composition recovery using the inner product signal WHX concerned. if a signal required for a RAKE composition recovery is prepared here as delay signals r0 (t+td1)-r0 (t+td6) -- an oppression of a signal unnecessary for a RAKE composition recovery sake -- null -- a point can be formed. Therefore, useless consumption of the degree of freedom of the adaptive array antenna of an MMSE method can be held down like the above-mentioned 1st operation gestalt.
[0111] In addition, the adaptive array antenna of an MMSE method is applied to the communication link of a CDMA method, and although the example which acquires the delay information on the CDMA input signal X (i) with a matched filter 100 was shown, you may make it acquire the delay information on the receiving OFDM signal of not only this but the above-mentioned 1st and 2nd operation gestalt with a matched filter 100 in the above-mentioned 4th operation gestalt.
[0112] (The 5th operation gestalt) Although the 2 above-mentioned operation gestalten explained the example which set up beforehand a request known signal and other known signal ****, you may make it choose a request known signal and other known signals among delay signal R (i) not only according to this but according to the receiving OFDM signal X (i).

[0113] The configuration in this case is shown in drawing 11 and drawing 12 . Drawing 11 shows the configuration of the adaptive array antenna of the MMSE method in a **** 5 operation gestalt. Drawing 12 shows the detail configuration of the request signal selection circuitry in drawing 11 (following and request signal selection circuitry 130).
[0114] As the adaptive array antenna of the MMSE method of a **** 5 operation gestalt is shown in drawing 11 , the request signal selection circuitry 130 is added to the circuit shown in drawing 3 . In drawing 11 , the same sign which drawing 3 shows shows the same object or a real target the same object.
[0115] A delay circuit 90 receives the preamble signal r0 from a generator 60 (i), and is the delay preamble signals OF (t+tS) and OF (t+2, tS). -- OF (t+U-tS) is generated. However, U is the delay preamble signal [as opposed to / are the natural number and / the preamble signal r0 (i)] OF (t+tS). -- Each time delay of OF (t+U-tS) is short compared with the guard interval period TG of an OFDM signal.
[0116] the receiving OFDM signal X (i) and delay preamble signal OF(t+tS) --OF (t+U-tS) input into the request signal selection circuitry 130 -- having -- the request signal selection circuitry 130 -- the receiving OFDM signal X (i) -- responding -- delay preamble signal OF(t+tS) -- request known signal r0 (i)' and delay signal R (i) are chosen among OF(s) (t+U-tS).
[0117] Specifically, the request signal selection circuitry 130 consists of Correlators 131a-131c, 132a-132c, 133a-133c, 134a-134c, adders (sigma) 135a-135c, a maximum judging machine 136, and a selection circuitry 137, as shown in drawing 12 .
[0118] Next, actuation of a **** 5 operation gestalt is explained with reference to drawing 12 . The example which adopted only four antenna elements called antenna elements 11-14, and adopted three delay preamble signals of the delay preamble signals OF (t+tS), OF (t+2, tS), and OF (t+3, tS) hereafter is explained. First, antenna elements 11-14 output the receiving OFDM signal x1 (i), x2 (i), x3 (i), and x4 (i), respectively.
[0119] Next, correlator 131a performs correlation detection of the delay preamble signal OF (t+tS) and the receiving OFDM signal x1 (i), and correlator 132a performs correlation detection of the delay preamble signal OF (t+tS) and receiving OFDM signal x2 (i). Correlator 133a performs correlation detection of the delay preamble signal OF (t+tS) and the receiving OFDM signal x3 (i), and correlator 134a performs correlation detection of the delay preamble signal OF (t+tS) and the receiving OFDM signal x4 (i).
[0120] Adder 135a adds the correlation detecting signal from each of Correlators 131a, 132a, 133a, and 134a, and outputs an addition signal. Here, the addition signal of adder 135a shows correlation with the delay preamble signal OF (t+tS), the receiving OFDM signal x1 (i), x2 (i), x3 (i), and x4 (i).
[0121] Next, correlator 131b performs correlation detection of the delay preamble signal OF (t+2, tS) and the receiving OFDM signal x1 (i), and correlator 132b performs correlation detection of the delay preamble signal OF (t+2, tS) and receiving OFDM signal x2 (i). Correlator 133b performs correlation detection of the delay preamble signal OF (t+2, tS) and the receiving OFDM signal x3 (i), and correlator 134b performs correlation detection of the delay preamble signal OF (t+2, tS) and the receiving OFDM signal x4 (i).
[0122] Adder 135b adds the correlation detecting signal from each of Correlators 131b, 132b, 133b, and 134b, and outputs an addition signal. The addition signal of adder 135b shows correlation with the delay preamble signal OF (t+2, tS), the receiving OFDM signal x1 (i), x2 (i), x3 (i), and x4 (i).
[0123] Next, correlator 131c performs correlation detection of the delay preamble signal OF (t+3, tS) and the receiving OFDM signal x1 (i), and correlator 132c performs correlation detection of the delay preamble signal OF (t+3, tS) and receiving OFDM signal x2 (i). Correlator 133c performs correlation detection of the delay preamble signal OF (t+3, tS) and the receiving OFDM signal x3 (i), and correlator 134c performs correlation detection of the delay preamble signal OF (t+3, tS) and the receiving OFDM signal x4 (i).
[0124] Adder 135c adds the correlation detecting signal from each of Correlators 131c, 132c, 133c, and 134c, and outputs an addition signal. The addition signal of adder 135c shows correlation with the delay preamble signal OF (t+3, tS), the receiving OFDM signal x1 (i), x2 (i), x3

(i), and x4 (i).
[0125] Next, the maximum judging machine 136 judges the addition signal (henceforth a maximum addition signal) which serves as maximum among each addition signal from Adders 135a-135c, and outputs the maximum recognition signal which shows this maximum addition signal to a selection circuitry 137. Among the delay preamble signals OF (t+tS), OF (t+2, tS), and OF (t+3, tS), a selection circuitry 137 chooses the delay preamble signal corresponding to a maximum recognition signal as request known signal r(i)', and outputs it. Furthermore, a selection circuitry 137 outputs two delay preamble signals except the delay preamble signal corresponding to a maximum recognition signal as other known signals R (i) among the delay preamble signals OF (t+tS), OF (t+2, tS), and OF (t+3, tS). Other actuation is substantially [as the above-mentioned 2nd operation gestalt] the same.
[0126] In addition, in the above-mentioned 5th operation gestalt, although the example which adopted four antenna elements 11-14 was explained, if the number of not only this but an antenna element is two or more pieces, it is good without limit. Furthermore, although the above-mentioned 5th operation gestalt explained per [which adopted three delay preamble signals OF (t+tS), OF (t+2, tS), and OF (t+3, tS)] example, any number of numbers of not only this but a delay preamble signal are good.
[0127] In addition, as correlator shown in a **** 5 operation gestalt, various correlators, such as slide correlator and a matched filter, may be applied in operation of this invention.
[0128] (The 6th operation gestalt) With a **** 6 operation gestalt, the circuit where the equalizing circuit (henceforth an equalizing circuit 120) was added is adopted as the circuit of the above-mentioned 2nd operation gestalt, by the equalizing circuit 120, others and a known signal are oppressed among the inner product signals WHX of an adder 30 (i), and the repressed signal is outputted as an output signal. The configuration in this case is shown in drawing 13 and drawing 14 .
[0129] Drawing 13 is drawing showing the configuration of the adaptive array antenna of the MMSE method of a **** 6 operation gestalt. Drawing 14 shows the detail configuration of the equalizing circuit 120 in drawing 13 . In drawing 13 , the same sign in drawing 3 shows the same object or a real target the same object.
[0130] With the **** 6 operation gestalt, the adaptive array antenna of an MMSE method is applied to the QPSK communication mode instead of an OFDM communication mode. For this reason, antenna elements 11-1M receive a QPSK signal (pilot signal).
[0131] Therefore, antenna elements 11-1M are replaced with the receiving OFDM signal X (i), and output the receiving QPSK signal X (i), respectively. Moreover, the generating circuit 60 outputs the pilot signal r0 of a QPSK signal (i) as a request known signal, and a delay circuit 90 outputs delay pilot signal R (i) for which only the request period was delayed to the pilot signal r0 of a QPSK signal (i) as other known signals. MMSE computing-element 40A updates the antenna weight WH and the signal weight AH similarly substantially with the above-mentioned 2nd operation gestalt. Moreover, the component excluding [an adder (sigma) 30] the both sides of a request pilot signal (request known signal) and its delay pilot signal (other known signals) among the receiving QPSK signals X (i) outputs a repressed signal as an inner product signal WHX. Moreover, the equalizing circuit 120 consists of delay machines (Z-1) 121-124, multipliers 125-128, and adders 129 and 130, as shown in drawing 14 . Next, actuation of the equalizing circuit 120 of a **** 6 operation gestalt is explained with reference to drawing 14 and drawing 15 .
[0132] Hereafter, as shown in drawing 15 (a), the example as which total with request pilot signal QP1 and the delay pilot signals QP2-QP5 was adopted is explained as an inner product signal WHX of an adder (sigma) 30.
[0133] Since four delay pilot signals of the delay pilot signals QP2-QP5 are adopted here, the signal weight (henceforth signal weight A (G)) of MMSE computing-element 40A in a **** 6 operation gestalt can be expressed with a formula 27. G is sampling timing (updating timing) (G=t1, t2, t3 --). Moreover, drawing 15 (b) shows the output of the delay machines 121-124 in timing t1-t5.
[0134]
[Equation 27] A(G) = -- ″-- a1 [ ] (G) -- a2 [ ] (G) -- a3 (G) -- a4 (G) --] -- T -- the QPSK

symbol ZA shown in drawing 15 (a) is first inputted into the delay machine 121 through an adder 130 to timing t1. That is, an equalizing circuit 120 can output the QPSK symbol ZA to timing t1.
[0135] Next, to timing t2, as shown in drawing 15 (b), the delay machine 121 outputs the QPSK symbol ZA to the delay machine 122 while outputting the QPSK symbol ZA to a multiplier 127. Then, a multiplier 128 carries out the multiplication of signal weight a1(t2) * to the QPSK symbol ZA, and outputs a multiplication signal (a1(t2) *ZA) to an adder 129.
[0136] Here, as the above-mentioned 1st operation gestalt described, signal weight a1(t2) * (signal weight AH) is called for so that MMSE computing-element 40A may show the phase contrast and the amplitude difference of the QPSK symbol ZA1 {delay signal R (i)} on the basis of the QPSK symbol ZA {the preamble signal r0 (i)}. For this reason, a multiplication signal (a1(t2) *ZA) becomes equal to the QPSK symbol ZA1 (ZA1=a1(t2) *ZA).
[0137] Thereby, a multiplier 128 can output the multiplication signal ZA1 to an adder 130 through an adder 129. Moreover, the QPSK symbols ZB and ZA1 are inputted into an adder 130 as an inner product signal WHX of an adder (sigma) 30. An adder 130 outputs a differential signal (= ZB) to the delay machine 121 in quest of the difference of the QPSK symbols ZB and ZA1 and the multiplication signal ZA1. That is, an equalizing circuit 120 can output the QPSK symbol ZB to timing t2.
[0138] Next, to timing t3, the delay machine 122 outputs the QPSK symbol ZA to the delay machine 123 while outputting the QPSK symbol ZA to a multiplier 127, as shown in drawing 15 (b). Then, a multiplier 127 carries out the multiplication of signal weight a2(t3) * to the QPSK symbol ZA, and outputs a multiplication signal (a2(t3) *ZA) to an adder 129.
[0139] Here, as the above-mentioned 1st operation gestalt described, signal weight a2(t3) *ZA (signal weight AH) is calculated so that MMSE computing-element 40A may show the phase contrast and the amplitude difference of the QPSK symbol ZA2 {delay signal R (i)} on the basis of the QPSK symbol ZA {the preamble signal r0 (i)}. For this reason, a multiplication signal (a2(t3) *ZA) becomes equal to the QPSK symbol ZA2 (ZA2=a2(t3) *ZA). Therefore, a multiplier 127 outputs the QPSK symbol ZA2 to an adder 129.
[0140] Moreover, the delay machine 121 outputs the QPSK symbol ZB to the delay machine 122 while outputting the QPSK symbol ZB to a multiplier 128, as shown in drawing 15 (b). A multiplier 128 carries out the multiplication of signal weight a1(t3) * to the QPSK symbol ZB, and outputs a multiplication signal (a1(t3) *ZB) to an adder 129.
[0141] Here, as the above-mentioned 1st operation gestalt described, signal weight a1(t3) * (signal weight AH) is called for so that MMSE computing-element 40A may show the phase contrast and the amplitude difference of the QPSK symbol ZB1 {delay signal R (i)} on the basis of the QPSK symbol ZB {the preamble signal r0 (i)}.
[0142] Therefore, a multiplication signal (a1(t3) *ZB) becomes equal to the QPSK symbol ZB1 (ZB1=a1(t3) *ZB). Therefore, a multiplier 127 can output the multiplication signal ZB1 to an adder 129.
[0143] Here, an adder 129 adds the multiplication signal ZB1 of a multiplier 127, and the QPSK symbol ZA2 of an adder 129, and outputs an addition signal (ZB1+ZA2) to an adder 130. The QPSK symbols ZC, ZB1, and ZA2 are inputted into an adder 130 as an inner product signal WHX of an adder (sigma) 30, and an adder 130 asks for the difference of the QPSK symbols ZC, ZB1, and ZA2 and an addition signal (ZB1+ZA2), and outputs a differential signal ZC to the delay machine 121.
[0144] That is, an equalizing circuit 120 can output the QPSK symbol ZC to timing t3. Hereafter, an equalizing circuit 120 operates similarly substantially with above-mentioned actuation, by timing t4, outputs the QPSK symbol ZD and outputs the QPSK symbol ZE to timing t5.
[0145] By the above, an equalizing circuit 120 can output only QPSK symbol ZA-ZD like ****. If it puts in another way, as an inner product signal WHX of an adder (sigma) 30, total with request pilot signal QP1 and the delay pilot signals QP2-QP5 will be inputted into an equalizing circuit 120, it will oppress the delay pilot signals QP2-QP5, and will output only request pilot signal QP1.

[0146] In addition, although the above-mentioned 6th operation gestalt explained the example which applied the adaptive array antenna of an MMSE method to the QPSK communication

mode, you may apply not only to this but to an OFDM communication mode.
[0147] Furthermore, it is in charge of operation of this invention, and various communication modes may be adopted in addition to an OFDM communication mode, a CDMA communication mode, the communication mode using a QPSK modulation, etc.
[0148] In addition, although the 1st - the 6th operation gestalt explained the example which adopted the SMI algorithm of an MMSE method with the MMSE computing elements 40A and 40B, other algorithms may be adopted as long as it is an MMSE method.
[0149] When an interference wave comes from the same direction as a request signal in the (7th operation gestalt) and time in the adaptive array antenna of the MMSE method stated with the above-mentioned 1st operation gestalt, there is a problem that the interference wave cannot be oppressed. namely, in the adaptive array antenna of the MMSE method stated with the above-mentioned 1st operation gestalt Although the component except the preamble signal r0 (i) and delay signal R (i) becomes a repressed signal among the receiving OFDM signals X (i), the inner product signal WHX of an adder 30 When a delay-GI outside signal (interference wave) comes from the same direction as the preamble signal r0 (i), the GI delay signal can be controlled.
[0150] It is well-known to oppress without distinguishing the request signal and interference wave which are contained in it in an incoming wave component in the adaptive array antenna of the conventional PI method. Then, in a **** 7 operation gestalt, it explains per [oppresses the interference wave which accomplished paying attention to the adaptive array antenna of the conventional PI method, and prevents oppression of the both sides of a request wave and the delay signal in GI, and comes from the same direction as a request signal and it is made to raise the communication link engine performance] example. The configuration in this case is shown in drawing 16 .
[0151] The adaptive array antenna of PI method is antenna elements 11-14 and a multiplier 21. -- It consists of 2M, an adder (sigma) 30, the PI computing element 41, adder 51A, multiplier 53A, and delay circuit 80A. In drawing 16 , the same sign as the sign in drawing 1 shows the same object or a substantial same object.
[0152] Delay circuit 80A outputs this preamble signal r0 (i) and delay signal R (i) in response to the preamble signal r0 (i) stated with the above-mentioned 1st operation gestalt. Hereafter, the output signal of delay circuit 80A is called output signal R(i)'.
[0153] However, like ****, the time delay of delay signal R (i) to a preamble signal is short compared with the period TG of the guard interval GI of an OFDM symbol, and sets the number (sample point size) of delay signal R (i) to 16.
[0154] Multiplier 53A carries out the multiplication of the signal weight AH to output signal R(i)', and searches for a multiplication signal {AHR(i)'}. Adder 51A adds a multiplication signal {AHR(i)'} and the inner product signal WHX of an adder 30 (i), and asks for an addition reference sign (WHX(i)+AHR(i)').
[0155] Addition reference-sign (WHX(i)+AHR(i)') and output signal R(i)' and the receiving OFDM signal X (i) are inputted into the PI computing element 41, and the PI computing element 41 updates the antenna weight W and the signal weight A so that power |WHX(i)+AHR(i)'|2 of an addition reference sign may be made into min. At this time, the signal weight A turns into weight which negates output signal R(i)' among the signal components contained in the inner product signal WHX (i), and the antenna weight W turns into weight which makes min power of the interference wave component contained in the receiving OFDM signal X (i).
[0156] If it puts in another way, the PI computing element 41 will update the antenna weight W and the signal weight A so that power of the component except output signal R(i)' may be made into min among the power (WHX(i)+AHR(i)') of an addition reference sign.
[0157] In drawing 17 , the result of a simulation when a request signal and a delay-GI outside signal come from the same is shown. In drawing 17 , when the 1st - the 5th wave come, the directivity after actuation of the adaptive array antenna of the adaptive array antenna of PI method and an MMSE method is shown. The receiving include angle [deg] of the received [a right longitudinal shaft] electric wave on the basis of the adaptive array antenna of an MMSE method and a left-vertical shaft are the receiving include angles [deg] of the received electric wave on the basis of the adaptive array antenna of PI method. An axis of abscissa is an

oppression ratio (dB).
[0158] In drawing 17 , since antenna gain differs, it expresses with the adaptive array antenna of an MMSE method, and the adaptive array antenna of PI method that the gain of the direction of delay ****** in GI becomes the same.
[0159] Here, the chain line shows the result of the simulation which used the adaptive array antenna of an MMSE method. A continuous line shows the result of the simulation which used the adaptive array antenna of PI method. Although the delay-GI outside signal of the same direction as a request signal is not oppressed in the adaptive array antenna of an MMSE method so that drawing 17 may show, the delay-GI outside signal of the same direction as a request signal is oppressed in the adaptive array antenna of PI method.
[0160] (The 8th operation gestalt) With the **** 8 operation gestalt, as shown in drawing 18 , low pass filters 420-425 are added to the configuration which the above-mentioned 7th operation gestalt shows. In drawing 18 , low pass filters 420-424 search for the OFDM signal signal of a narrow-band based on the receiving OFDM signal X (i).
[0161] Low pass filters 420-424 output a narrow-band OFDM signal signal by taking out only the component (referring to drawing 19) of the predetermined frequency band among the receiving OFDM signals X (i). That is, the OFDM signal signal of a narrow-band turns into a signal which narrowed the frequency band of the receiving OFDM signal X (i).
[0162] A low pass filter 425 searches for a narrow-band preamble signal based on the preamble signal r0 (i). that is, the low pass filter 425 -- the preamble signal r0 (i) -- a narrow-band preamble signal is outputted by taking out only the component of the predetermined frequency band inside.
[0163] In connection with this, delay circuit 80A searches for the delay signal of U (drawing 19 8) individual which has a different time delay to a narrow-band preamble signal, and outputs the both sides of this delay signal and a narrow-band preamble signal as output signal R(i)'. However, the time delay of the delay signal over a preamble signal is short like **** compared with the period TG of the guard interval GI of an OFDM symbol.
[0164] Here, among output signal R(i)', the number of adoption of a delay signal (sample point) can be reduced, if it is decided by the frequency band of the receiving OFDM signal X (i) and the frequency band is narrowed.
[0165] then -- **** -- eight -- operation -- a gestalt -- PI -- a computing element -- 41 -- an antenna -- weight -- W -- and -- a signal -- weight -- A -- updating -- hitting -- OFDM -- a signal -- a signal -- replacing with -- a narrow-band -- OFDM -- a signal -- a signal -- adopting -- a preamble -- a signal -- having been based -- an output signal -- R -- (-- i --) -- ' -- replacing with -- a narrow-band -- a preamble -- a signal -- having been based -- an output signal -- R -- (-- i --) -- ' -- adopting . For this reason, not to mention reducing the number of adoption of R (i), it becomes possible about the antenna weight W and the signal weight A to reduce the count of updating, and the computational complexity of renewal of weight can be reduced.
[0166] (The 9th operation gestalt) Although the above-mentioned 3rd operation gestalt explained the adaptive array antenna of the MMSE method which adopted the pudding AMBURU signal of an OFDM signal as a signal on a time-axis, a **** 9 operation gestalt explains per adaptive array antenna of PI method which adopted each discrimination signal which carried out FFT processing (frequency judgment) of the pudding bull signal of not only this but an OFDM signal. The configuration in this case is shown in drawing 20 .
[0167] The adaptive array antenna of PI method consists of antenna elements 11-14, a multiplier 201--204, an adder (sigma) 300, the FFT circuits 801-804, the FFT circuit 834, the PI computing element 42, adder 510A, multiplier 530A, and delay circuit 80A. In drawing 20 , the same sign as the sign in drawing 5 shows the same object.
[0168] As the above-mentioned 8th operation gestalt described, delay circuit 80A combines the preamble signal r0 (i) and delay signal R (i), and outputs them as output signal R(i)'. The FFT circuit 834 samples each effective symbol of the preamble signal r0 (i) and delay signal R (i) with a sampling period tS in juxtaposition, carries out FFT processing by the sampling signal, and outputs the discrimination signal RFT (i).

[0169] Multiplier 530A carries out the multiplication of the signal weight AH to the discrimination signal RFT (i), and searches for a multiplication signal {AHRFT (i)}. Adder 510A adds multiplication signal {AHRFT (i)} and inner product signal [of an adder 300] WHX (i)', and asks for an addition reference sign (WHX(i)'+AHRFT (i)).
[0170] Discrimination signal X (i)', and an addition reference sign (WHX (i) '+AHRFT (i)') and the discrimination signal RFT (i) are inputted into the PI computing element 42, and the PI computing element 42 updates the antenna weight W and the signal weight A so that power |WHX (i)'+AHRFT(i)'|2 of an addition reference sign may be made into min. At this time, the signal weight A turns into weight which negates the discrimination signal RFT (i) among the signal components contained in inner product signal WHX (i)', and the antenna weight W turns into weight which makes min power of the interference wave component contained in discrimination signal X (i)'.
[0171] If it puts in another way, the PI computing element 42 will update the antenna weight W and the signal weight A so that power of the component except the discrimination signal RFT (i) may be made into min among addition reference signs (WHX (i) '+AHRFT (i)').
(The 10th operation gestalt) The adaptive array antenna of the SMI method in a **** 10 operation gestalt consists of antenna elements 11 and 12, a generator 60, the FFT circuits 83, 801, and 802, multipliers 201 and 202, an adder (sigma) 300, the phase revolution machine 1000, correlator 1010, a selection circuitry 1020, and a computing element 1030, as shown in drawing 21 .
[0172] A computing element 1030 has the matrix-of-correlation presumption machine 1031, the inverse-matrix computing element 1032, the correlation vector presumption machine 1033, and the matrix multiplication machine 1034. In addition, in drawing 21 , the same sign in drawing 1 and drawing 2 shows the same object.
[0173] First, FFT processing of the pudding AMBURU signal of the receiving OFDM signal x1 (i) received by the antenna element 11 is carried out in the FFT circuit 801, and the discrimination signal ft1 (1), ft1 (2), ft1 (3), and ft1 (4) are calculated for every frequency. Moreover, FFT processing of the receiving OFDM signal x2 (i) received by the antenna element 12 is carried out in the FFT circuit 802, and the discrimination signal ft2 (1), ft2 (2), ft2 (3), and ft2 (4) are calculated for every frequency. In addition, the figure 1--4 in the parenthesis of a discrimination signal shows the point size of FFT.
[0174] Here, the vector notation of receiving OFDM signal x1(i) x2(i) discrimination signal ft1(1) -ft1 (3) and the discrimination signal ft2(1) -ft2 (3) is carried out as follows.
[0175]
[Equation 28] X(i) = [x1(i) x2 (i)] T [0176]
[Equation 29] FT1 (i) = [ft1(1) ft1(2) ft1 (3)] T [0177]
[Equation 30] The FT2(i) =[ft2(1) ft2(2) ft2 (3)] T multiplier 201 asks for the matrix product (w1*FT1 (i)) of antenna weight w1* and FT1 (i), and a multiplier 202 asks for the matrix product (w2*FT2 (i)) of antenna weight w2* and FT2 (i).
[0178] Next, an adder (sigma) 300 adds the matrix product (w1*FT1 (i)) by multipliers 201 and 202, and (w2*FT2 (i)) for every frequency. namely, -- a matrix -- a product (w1*FT1 (i)) -- (-- w -- two -- * -- FT -- two -- (-- i --) --) -- an antenna -- weight -- w -- one -- * -- w -- two -- * -- a formula -- 31 -- 32 -- like -- a vector -- a notation -- carrying out -- if -- an adder (sigma) -- 300 -- an antenna -- weight -- W -- discrimination -- a signal -- X -- (-- i --) -- ' -- an inner product -- being shown -- an inner product -- a signal -- WHX -- (-- i --) -- ' -- asking -- having . Moreover, as shown in a formula 33, the vector notation of inner product signal WHX (i)' is carried out.
[0179]
[Equation 31]
X(i)'= [FT1(i) FT2 (i)] T [0180]
[Equation 32] W= [w1 w2] T [0181]
[Equation 33] WHX(i)'= [w1*ft1(1)+w2*ft2(1) w1*ft1(2)+w2*ft2(2) w1*ft1(3)+w2*ft2 (3)] T, next a generator 60 as a request known signal Generating the preamble signal r0 of an OFDM signal (i), this preamble signal r0 (i) is a signal with which two or more pilot symbols (known signal) were

arranged on the frequency shaft. Moreover, the FFT circuit 83 carries out FFT processing of the preamble signal r0 of an OFDM signal (i), and calculates the request discrimination signal rf1 (1), rf1 (2), and rf1 (3) for every frequency.
[0182] Next, only four sorts of amounts of phases (0degreetheta**, 2theta** 3theta**) carry out revolution processing of the request discrimination signal rf1 (1), and the phase revolution machine 1000 outputs these request discrimination signals rf1 (1 theta), rf1 (1 2theta), and rf1 (1 3theta) by which revolution processing was carried out, and the request discrimination signal rf1 (1).
[0183] Furthermore, only four sorts of amounts of phases (0 degree, theta**, 2theta**, 3theta**) carry out revolution processing of the request discrimination signal rf1 (2), and the phase revolution machine 1000 outputs these request discrimination signals rf1 (2 theta), rf1 (2 2theta), and rf1 (2 3theta) by which revolution processing was carried out, and the request discrimination signal rf1 (2).
[0184] Moreover, only four sorts of amounts of phases (0degreetheta**, 2theta** 3theta**) carry out revolution processing of the request discrimination signal rf1 (3), and the phase revolution machine 1000 outputs these request discrimination signals rf1 (3 theta), rf1 (3 2theta), and rf1 (3 3theta) by which revolution processing was carried out, and the request discrimination signal rf1 (3).
[0185] Here, request discrimination signal rf1(1) -rf1 (1 3theta), rf1(2) -rf1 (2 3theta), and rf1(3) -rf1 (3 3theta) are calculated as shown in a formula 34.
[0186]
[Equation 34]

$$BS=\begin{bmatrix} C_{11} & C_{12} & C_{13} \\ C_{21} & C_{22} & C_{23} \\ C_{31} & C_{32} & C_{33} \\ C_{41} & C_{42} & C_{43} \end{bmatrix} \begin{bmatrix} rf_1(1) & 0 & 0 \\ 0 & rf_1(2) & 0 \\ 0 & 0 & rf_1(3) \end{bmatrix}$$

[0187] However, the amount of phases which shows Ctf in a formula 35, the number t indicates the amount of phases to be, and f are numbers which show a frequency. Moreover, they are C11=C12=C13, C21=C22=C23, and C31=C32=C33 with a formula 35.
[0188]
[Equation 35] Ctf=exp {-2pij-(j-1) - (t-1)/3}
Here, the output signal of the phase revolution machine 1000 is equivalent to what combined the output signal of the FFT circuit 84 and the output signal of the FFT circuit 83 which are shown in drawing 5 . That is, the FFT circuit 84 generates a time delay shorter than the guard interval period TG to the preamble signal r0 (i) with the phase revolution machine 1000, and plays a role equivalent to carrying out FFT processing of this generated time delay.
[0189] Next, correlator 1010 calculates the correlation value K of the request processing signal BS and discrimination signal X (i)'. In addition, the correlation value K is calculated by the matrix product (BSxX (i) ') of the request processing signal BS and discrimination signal X (i)'.
[0190] Based on the correlation value K, as for a selection circuitry 1020, the request processing signal BSmax with the largest correlation with discrimination signal X (i)' among the request processing signals BS is searched for for every frequency.
[0191] For example, the vector notation of the correlation value K is carried out like a formula 36. The number t indicates the amount of phases to be in the correlation value ktf, and f are numbers which show a frequency among a formula 36.
[0192]
[Equation 36]

$$K=\begin{bmatrix} K_{11} & K_{12} \\ K_{21} & K_{22} \\ K_{31} & K_{32} \\ K_{41} & K_{42} \end{bmatrix}$$

[0193] First, a selection circuitry 1020 adds the square value (**ktf** 2) of an absolute value for every amount of phases respectively, and searches for the matrix KG which shows in a formula 37 while it calculates each absolute value of the correlation value ktf and calculates the square value (**ktf** 2) of each absolute value.
[0194]
[Equation 37]

$$KG=\begin{bmatrix} |K_{11}|^2+|K_{12}|^2 \\ |K_{21}|^2+|K_{22}|^2 \\ |K_{31}|^2+|K_{32}|^2 \\ |K_{41}|^2+|K_{42}|^2 \end{bmatrix}$$

[0195] Next, a selection circuitry 1020 searches for the request discrimination signal (henceforth the request discrimination signal MX) corresponding to the amount of phases of maximum for every frequency among Matrices BS while calculating maximum among Matrices KG.
[0196] Here, it is the request discrimination signal rf1 (1). -- rf1 (2) -- The vector notation of the matrix BS which shows rf1 (3 3theta) is carried out like a formula 38.
[0197]
[Equation 38]

$$BS=\begin{bmatrix} rf_1(1) & rf_1(2) & rf_1(3) \\ rf_1(1\ \theta) & rf_1(2\ \theta) & rf_1(3\ \theta) \\ rf_1(1\ 2\theta) & rf_1(2\ 2\theta) & rf_1(3\ 2\theta) \\ rf_1(1\ 3\theta) & rf_1(2\ 3\theta) & rf_1(3\ 3\theta) \end{bmatrix}$$

[0198] as the maximum of for example, the matrix KG -- [-- the time of ** k21 ** 2+ ** k22 ** 2] being chosen -- the inside of a formula 38 -- as the request discrimination signal MX for every frequency (i) -- [-- rf1 (12theta) rf1 (2 2theta) and rf1(3 2theta)] are chosen. Furthermore, as request discrimination signals other than the request discrimination signal MX for every frequency (i) are shown in a formula 39 among formulas 38, it considers as the request processing signal BA. However, the request processing signal BA of a formula 39 shows an example as which [rf1 (1 2theta) rf1 (2 2theta) and rf1(3 2theta)] were chosen as a request discrimination signal MX (i).
[0199]
[Equation 39]

$$BA=\begin{bmatrix} rf_1(1) & rf_1(2) & rf_1(3) \\ rf_1(1\ \theta) & rf_1(2\ \theta) & rf_1(3\ \theta) \\ rf_1(1\ 3\theta) & rf_1(2\ 3\theta) & rf_1(3\ 3\theta) \end{bmatrix}$$

[0200] In addition, hereafter, in order to give explanation simply, as shown in a formula 40, the vector notation of the request processing signal BA (i) is carried out, and as shown in a formula 41, the vector notation of the request discrimination signal MX (i) is carried out. The number t indicates the amount of phases to be in the correlation value batf, and f are numbers which show a frequency among a formula 40. In mxt, t is a number which shows the amount of phases among a formula 41.
[0201]
[Equation 40]

$$BA(i)=\begin{bmatrix} ba_{11}(i) & ba_{21}(i) & ba_{31}(i) \\ ba_{12}(i) & ba_{22}(i) & ba_{32}(i) \\ ba_{13}(i) & ba_{23}(i) & ba_{33}(i) \end{bmatrix}$$

[0202]

[Equation 41]

$$MX(i) = \begin{bmatrix} mx_1 & mx_2 & mx_3 \end{bmatrix}$$

[0203] In addition, hereafter, as shown in a formula 42, the vector notation of discrimination signal X (i)' is carried out. However, M of ftMf in a formula 42 shows the number of an antenna element with the natural number, and f shows a frequency.
[0204]
[Equation 42]

$$X(i)' = \begin{bmatrix} ft_{11}(i) & ft_{12}(i) & ft_{13}(i) \\ ft_{21}(i) & ft_{22}(i) & ft_{23}(i) \end{bmatrix}$$

[0205] Next, the matrix-of-correlation presumption machine 1031 combines discrimination signal X (i)' and the request processing signal BA, and it asks for the instant input matrices RXMXM1, RXMXM2, and RXMXM3 in each time of day in Matrix XM with a formula 44, a formula 45, and a formula 46 while it generates the matrix XM shown in a formula 43. Based on a formula 47, the instant input matrices RXMXM1, RXMXM2, and RXMXM3 are equalized, and the estimate RXMXM of a matrix of correlation is calculated.
[0206]
[Equation 43]

$$XM(i) = \begin{bmatrix} X'(i) \\ BA(i) \end{bmatrix} = \begin{bmatrix} ft_{11}(i) & ft_{12}(i) & ft_{13}(i) \\ ft_{21}(i) & ft_{22}(i) & ft_{23}(i) \\ ba_{11}(i) & ba_{21}(i) & ba_{31}(i) \\ ba_{12}(i) & ba_{22}(i) & ba_{32}(i) \\ ba_{13}(i) & ba_{23}(i) & ba_{33}(i) \end{bmatrix}$$

[0207]
[Equation 44] RXMXM1=XM(1) and XM (1) H [0208]
[Equation 45] RXMXM2=XM(2) and XM (2) H [0209]
[Equation 46] RXMXM3=XM(3) and XM (3) H [0210]
[Equation 47]
RXMXM= (RXMXM1+RXMXM2+RXMXM3)/3, next the inverse-matrix computing element 1032 calculate inverse-matrix RXMXM-1 of the estimate RXMXM of a matrix of correlation. Moreover, the correlation vector presumption machine 1033 searches for discrimination signal X (i)' and the instant correlation vectors [in / as shown in a formula 48, a formula 49, and a formula 50 using the request discrimination signal MX and the request discrimination signal BA / each time of day] rxmb1, rxmb2, and rxmb3.
[0211] Next, based on a formula 51, the correlation vector presumption machine 1033 equalizes the instant correlation vectors rxmb1, rxmb2, and rxmb3 on a frequency, and calculates the correlation vector estimate rxmb.
[0212]
[Equation 48] rxmb1=XM(1) and MX (1) H [0213]
[Equation 49] rxmb2=XM(2) and MX (2) H [0214]
[Equation 50] rxmb3=XM(3) and MX (3) H [0215]
[Equation 51] It outputs "w1* w2*" to multipliers 201 and 202 among the multiplication results Z at it, respectively while matrix multiplication of the matrix multiplication machine 1034 is carried out to the rxmb= (rxmb1+rxmb2+rxmb3) / 3 last and it asks it for the multiplication result Z with the estimate RXMXM of a matrix of correlation, and the correlation vector estimate rxmb, as shown in a formula 52. In addition, the inside of a formula 51, -a1 - a2 - a3 -a4 are the signal weight stated to the above-mentioned 3rd operation gestalt.
[0216]
[Formula 52]

It can Z=[w1* w2*-a1 -a2 -a3 -a4] T Come, and are alike. More multipliers 201 and 202 It asks for a matrix product (w1*FT1 (i)) and a matrix product (w2*FT2 (i)), respectively, and by the adder (sigma) 300, a matrix product (w1*FT1 (i)) and (w2*FT2 (i)) are added for every frequency, and inner product signal WHX (i)' is called for.

[0217] The antenna weight w1 and w2 are updated so that the component except the request processing signal BA and the request discrimination signal MX may be oppressed among inner product signal WHX (i)' here. This prevents oppression with the request processing signal BA and the request discrimination signal MX without the need for oppression, and as substantially as the above-mentioned 1st and 2nd operation gestalt, since the signal component which originally has the need for oppression similarly can be oppressed, the Nur point can be formed in an effective target. Therefore, useless consumption of the degree of freedom of the adaptive array antenna of an SMI method can be held down.

[0218] For example, as shown in [alpha] drawing 22 , directivity can be formed by antenna elements 11 and 12.

[0219] That is, delay-GI outside signals other than the request processing signals BA and MX are oppressed among inner product signal WHX (i)', without oppressing the request discrimination signal MX. However, if a delay-GI outside signal and the request processing signal BA are received from the same, both a delay-GI outside signal and the request processing signal BA will be oppressed. Thus, among inner product signal WHX (i)', although the request discrimination signal MX is not oppressed and is left behind, the request processing signal BA may be oppressed depending on a receive direction.

[0220] Furthermore, the component of the request discrimination signal MX is left behind at least among inner product signal WHX (i)' by the antenna weight w1 and renewal of w2, and it is obtained. Here, since correlation with discrimination signal X (i)' is the largest signal among the request processing signals BS like ****, a signal with big receiving level can acquire the request discrimination signal MX as a component of the request discrimination signal MX among discrimination signal X (i)' by leaving behind the component of the request discrimination signal MX. Therefore, it can restore to the component of the request discrimination signal MX good.

[0221] In the above-mentioned 11th operation gestalt, the FFT circuits 801 and 802 are adopted and adaptive AREANTENA of an SMI method is constituted. In addition, the FFT circuits 801 and 802 Although explained per [which carries out FFT processing of the receiving OFDM signal x1 (i), and asks for the antenna weight w1 and w2 based on the signal on this frequency shaft by which FFT processing was carried out, respectively] example, you may make it be not only this but the following.

[0222] That is, without adopting the FFT circuits 801 and 802, adaptive AREANTENA of an SMI method is constituted, the receiving OFDM signal x1 (i) is replaced with the signal on the frequency shaft which carried out FFT processing, the receiving OFDM signal x1 on a time-axis (i) is adopted, and you may make it ask for the receiving OFDM signal x1(i) antenna weight w1 and w2 on a time-axis.

(The 11th operation gestalt) With the **** 11 operation gestalt, as shown in drawing 22 , low pass filters (LPF) 1040 and 1041 are added to the configuration which the above-mentioned 10th operation gestalt shows.

[0223] In drawing 22 , a low pass filter 1040 searches for the discrimination signal LF 1 of a narrow-band {=ft1 (1), ft1 (2)} based on discrimination signal ft1(1) -ft1 from the FFT circuit 801 (3). With this, a low pass filter 1040 searches for the discrimination signal LF 2 of a narrow-band {=ft2 (1), ft2 (2)} based on discrimination signal ft2(1) -ft2 from the FFT circuit 802 (3).

[0224] By this, a low pass filter 1040 will output the discrimination signal LF of the narrow-band shown in a formula 53. That is, a low pass filter 1040 outputs the discrimination signals LF1 and LF2 of a narrow-band by taking out only the component of a predetermined frequency band among discrimination signal ft1(1) -ft1(3) ft2(1) -ft(s)2 (3).

[0225]

[Equation 53]

$$LF=\begin{bmatrix} LF_1 \\ LF_2 \end{bmatrix}=\begin{bmatrix} ft_1(1) & ft_1(2) \\ ft_2(1) & ft_2(2) \end{bmatrix}$$

[0226] Moreover, it connects between the FFT circuit 83 and the phase revolution machine 1000, and a low pass filter 1041 searches for the discrimination signal rLF of a narrow-band {=rf1 (1), rf1 (2)} based on the request discrimination signal rf1 from the FFT circuit 83 (1), rf1 (2), and rf1 (3). That is, a low pass filter 1041 outputs the discrimination signal rf1 of a narrow-band (1), and rf1 (2) by taking out only the component of a predetermined frequency band among the request discrimination signal rf1 (1), rf1 (2), and rf1 (3).
[0227] Next, only four sorts of amounts of phases (0 degree, theta**, 2theta**, 3theta**) carry out revolution processing of the request discrimination signal rf1 (1), and the phase revolution machine 1000 outputs these request discrimination signals rf1 (1 theta), rf1 (1 2theta), and rf1 (1 3theta) by which revolution processing was carried out, and the request discrimination signal rf1 (1).
[0228] Furthermore, only four sorts of amounts of phases (0 degree, theta**, 2theta**, 3theta**) carry out revolution processing of the request discrimination signal rf1 (2), and the phase revolution machine 1000 outputs these request discrimination signals rf1 (2 theta), rf1 (2 2theta), and rf1 (2 3theta) by which revolution processing was carried out, and the request discrimination signal rf1 (2).
[0229] In addition, hereafter, request discrimination signal rf1(1) -rf1 (1 3theta) and rf1(2) -rf1 (2 3theta) are made into the request processing signal LBS, as shown in a formula 54.
[0230]
[Equation 54]

$$LBS=\begin{bmatrix} rf_1(1) & rf_1(2) \\ rf_1(1\ \theta) & rf_1(2\ \theta) \\ rf_1(1\ 2\theta) & rf_1(2\ 2\theta) \\ rf_1(1\ 3\theta) & rf_1(2\ 3\theta) \end{bmatrix}$$

[0231] next -- **** -- 11 -- operation -- a gestalt -- correlator -- 1010 -- the above -- the -- ten -- operation -- a gestalt -- having stated -- a request -- processing -- a signal -- BS -- replacing -- a request -- processing -- a signal -- LBS -- discrimination -- a signal -- X -- (-- i --) -- ' -- replacing -- a narrow-band -- discrimination -- a signal -- rLF -- correlation -- a value -- K -- ' -- asking . moreover -- a selection circuitry -- 1020 -- the above -- the -- ten -- operation -- a gestalt -- substantial -- the same -- correlation -- a value -- K -- ' -- being based -- a request -- processing -- a signal -- LBS -- inside -- a narrow-band -- discrimination -- a signal -- rLF -- correlation -- most -- being large -- a frequency -- every -- a request -- discrimination -- a signal -- MX -- ' -- asking . Furthermore, it asks for request processing signal BA' other than request processing signal MX' among the request processing signals LBS.
[0232] Next, in a computing element 1030, while it replaces with discrimination signal X (i)', and the discrimination signal rLF of a narrow-band is inputted, replacing with the request processing signal MX and inputting request processing signal MX', it replaces with the request processing signal BA, and request processing signal BA' is inputted.
[0233] Then, the matrix-of-correlation presumption machine 1031 calculates inverse-matrix RXMXM-1 of the estimate RXMXM of a matrix of correlation while calculating [gestalt / above-mentioned / 10th operation] the estimate RXMXM of a matrix of correlation substantially similarly based on the discrimination signal rLF of a narrow-band, and request processing signal MX' with the correlation vector presumption machine 1033 and the inverse-matrix computing element 1032.
[0234] Moreover, the correlation vector estimate rxmb is calculated using the discrimination signal rLF of a narrow-band, request discrimination signal MX', and request discrimination signal BA' as substantially [the correlation vector presumption machine 1033] as the above-

mentioned 10th operation gestalt similarly. Furthermore, with the matrix multiplication vessel 1034, matrix multiplication of the estimate RXMXM of a matrix of correlation and the correlation vector estimate rxmb is carried out, antenna weight w1 w2 are calculated, and it is outputted to multipliers 201 and 202, respectively.
[0235] Since the component except the request processing signal BA and the request discrimination signal MX is oppressed among inner product signal WHX (i)' by the above, the same effectiveness is substantially acquired with the above-mentioned 10th operation gestalt. Furthermore, since the component of request discrimination signal MX' is left behind at least among inner product signal WHX (i)' and it is obtained, it can restore to the component of the request discrimination signal MX good substantially similarly with the above-mentioned 10th operation gestalt.
[0236] Moreover, while replacing with the request processing signal BS and adopting the request processing signal LBS in the operation of the correlation value of correlator 1010, it replaces with discrimination signal X (i)', and the discrimination signal rLF of a narrow-band is adopted. Here, like ****, the request processing signal LBS has a narrow frequency domain compared with the request processing signal BS, and the discrimination signal rLF of a narrow-band has a frequency domain narrow [the signal] like **** compared with discrimination signal X (i)'. For this reason, the amount of operations of the correlation value of correlator 1010 can be reduced compared with the above-mentioned 10th operation gestalt.
[0237] Furthermore, since correlation value K' of correlator 1010, the request processing signal LBS, and the discrimination signal rLF of a narrow-band are adopted when a selection circuitry 1020 asks for request processing signal MX'BA', the amount of operations of a selection circuitry 1020 can be reduced compared with the above-mentioned 10th operation gestalt.
[0238] Moreover, when a computing element 1030 calculates antenna weight w1 w2, while replacing with discrimination signal X (i)' and adopting the discrimination signal rLF of a narrow-band, it replaces with the request processing signal MX, and request processing signal MX' is adopted. For this reason, the amount of operations of a computing element 1030 can be reduced compared with the above-mentioned 10th operation gestalt.
(The 12th operation gestalt) With a **** 12 operation gestalt, the low pass filters (LPF) 1040 and 1041 stated with the above-mentioned 11th operation gestalt are adopted, and it explains per [which constitutes the adaptive array antenna of PI method] example. The configuration in this case is shown in drawing 23 .
[0239] The adaptive array antenna of PI method in a **** 12 operation gestalt consists of antenna elements 11 and 12, a generator 60, the FFT circuits 83, 801, and 802, multipliers 201 and 202, an adder (sigma) 300, a phase revolution machine 1000, low pass filters (LPF) 1040 and 1041, and computing-element 1030A. Computing-element 1030A has matrix-of-correlation presumption machine 1031A, inverse-matrix computing-element 1032A, and matrix multiplication machine 1034A. In addition, in drawing 23 , the same sign in drawing 1 , drawing 2 , and drawing 22 shows the same object.
[0240] First, like the above-mentioned 11th operation gestalt, while a low pass filter 1040 searches for the discrimination signal LF 1 of a narrow-band {=ft1 (1), ft1 (2)} based on discrimination signal ft1(1) -ft1 from the FFT circuit 801 (3) Based on discrimination signal ft2(1) -ft2 from the FFT circuit 802 (3), the discrimination signal LF 2 of a narrow-band {=ft2 (1), ft2 (2)} is searched for.
[0241] Next, the phase revolution machine 1000 searches for the request processing signal LBS shown in a formula 53 like the above-mentioned 11th operation gestalt based on the discrimination signal rLF of the narrow-band from a low pass filter 1041 {=rf1 (1), rf1 (2)}.
[0242] Next, it computing-element 1030A Sets and matrix-of-correlation presumption machine 1031A combines the discrimination signals LF1 and LF2 and the request processing signal LBS of a narrow-band, and while generating the matrix FB shown in a formula 55, the above-mentioned 10th operation gestalt and the substantial estimate [in / similarly / Matrix FB] RFBFB of a matrix of correlation are calculated.
[0243]
[Equation 55]

$$FB = \begin{bmatrix} LF_1 \\ LF_2 \\ LBS \end{bmatrix} = \begin{bmatrix} ft_1(1) & ft_1(2) \\ ft_2(1) & ft_2(2) \\ rf_1(1) & rf_1(2) \\ rf_1(1\ \theta) & rf_1(2\ \theta) \\ rf_1(1\ 2\theta) & rf_1(2\ 2\theta) \\ rf_1(1\ 3\theta) & rf_1(2\ 3\theta) \end{bmatrix}$$

[0244] Next, inverse-matrix computing-element 1032A calculates inverse-matrix RFBFB-1 of the estimate RFBFB of a matrix of correlation. Furthermore, matrix multiplication machine 1034A outputs antenna weight w1 w2 to multipliers 201 and 202 among multiplication result Z', respectively while asking for multiplication result Z' using the formula showing in a formula 56. In addition, the inside of a formula 55, -a1 -a2-a3 - a4 is the signal weight AH stated to the above-mentioned 9th operation gestalt.
[0245] Here, antenna weight w1 w2 are updated so that power of the component except the request processing signal LBS may be made into min among inner product signal [of an adder circuit 300] WHX (i)'.
[0246]
[Equation 56]

$$\begin{aligned} Z' &= [1 \quad 0 \quad 0 \quad 0]^T \times R_{FBFB}^{-1} \\ &= [w_1^* \ w_2^* \ -a_1 \ -a_2 \ -a_3 \ -a_4]^T \end{aligned}$$

Furthermore, when computing-element 1030A calculates antenna weight w1 w2, while the discrimination signal rLF of a narrow-band is adopted, the request processing signal LBS is adopted. The frequency band of the discrimination signal rLF of a narrow-band is narrow here compared with the frequency band of discrimination signal X (i)' stated with the above-mentioned 10th operation gestalt, and the frequency band of the request processing signal LBS is narrow compared with the frequency band of the request processing signal BS stated with the above-mentioned 10th operation gestalt. Therefore, computing-element 1030A can reduce the amount of operations compared with the time of using discrimination signal X (i)' and the request processing signal BS.
[0247] In addition, if it is two or more pieces as the number of antenna elements in operation of this invention, it is good without limit.
[0248] Furthermore, in carrying out frequency discrimination of the various signals, the example which adopted FFT processing was explained with each above-mentioned operation gestalt, but various kinds of frequency discrimination processings, such as not only this but DFT processing, may be adopted.

[Translation done.]

* NOTICES *

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1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is drawing showing the configuration of the adaptive array antenna of the MMSE method of the 1st operation gestalt of this invention.
[Drawing 2] It is drawing showing the result of the simulation of the adaptive array antenna of the MMSE method of the above-mentioned 1st operation gestalt.
[Drawing 3] It is drawing showing the configuration of the adaptive array antenna of the MMSE method of the 2nd operation gestalt of this invention.
[Drawing 4] It is drawing showing the detail configuration of the delay circuit shown in drawing 3 .

[Drawing 5] It is drawing showing the configuration of the adaptive array antenna of the MMSE method of the 3rd operation gestalt of this invention.
[Drawing 6] It is drawing showing the detail configuration of the FFT circuit shown in drawing 5 .
[Drawing 7] It is drawing showing actuation of the delay circuit shown in drawing 5 .
[Drawing 8] It is drawing showing actuation of the FFT circuit shown in drawing 6 .
[Drawing 9] It is drawing showing the configuration of the adaptive array antenna of the MMSE method of the 4th operation gestalt of this invention.
[Drawing 10] It is drawing showing actuation of the matched filter and delay circuit which are shown in drawing 9 .
[Drawing 11] It is drawing showing the configuration of the adaptive array antenna of the MMSE method of the 5th operation gestalt of this invention.
[Drawing 12] It is drawing showing the detail configuration of a request signal selection circuitry shown in drawing 11 .
[Drawing 13] It is drawing showing the configuration of the adaptive array antenna of the MMSE method of the 6th operation gestalt of this invention.
[Drawing 14] It is drawing showing the detail configuration of the equal circuit shown in drawing 13 .
[Drawing 15] It is drawing showing actuation of the equal circuit shown in drawing 14 .
[Drawing 16] It is drawing showing the configuration of the adaptive array antenna of PI method of the 7th operation gestalt of this invention.
[Drawing 17] It is drawing showing the result of the simulation of the adaptive array antenna of PI method of the above-mentioned 7th operation gestalt.
[Drawing 18] It is drawing showing the configuration of the adaptive array antenna of PI method of the 8th operation gestalt of this invention.
[Drawing 19] It is drawing showing actuation of LPF of drawing 18 .
[Drawing 20] It is drawing showing the configuration of the adaptive array antenna of PI method of the 9th operation gestalt of this invention.
[Drawing 21] It is drawing showing the configuration of the adaptive array antenna of the SMI method of the 10th operation gestalt of this invention.
[Drawing 22] It is drawing for explaining actuation of the above-mentioned 10th operation gestalt.
[Drawing 23] It is drawing showing the configuration of the adaptive array antenna of the SMI

method of the 11th operation gestalt of this invention.
[Drawing 24] It is drawing showing the configuration of the adaptive array antenna of PI method of the 11th operation gestalt of this invention.
[Drawing 25] It is drawing showing a format of an OFDM signal.
[Drawing 26] It is drawing for explaining the input signal of the adaptive array antenna of an MMSE method.
[Drawing 27] It is drawing showing the configuration of the adaptive array antenna of the conventional MMSE method.
[Description of Notations]
40 A--MMSE computing element, 30, 51, 52 -- 60 An adder, 70 -- Generator.

[Translation done.]